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1959

LIMESTONE RESOURCES OF EXTREME SOUTHERN ILLINOIS

J. E. Lamar

REPORT OF INVESTIGATIONS 211

ILLINOIS STATE GEOLOGICAL SURVEY
JOHN C. FRYE, *Chief* URBANA, ILLINOIS

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Urbana, Illinois 1959

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CONTENTS

ILLUSTRATIONS

TABLES

LIMESTONE RESOURCES OF EXTREME SOUTHERN ILLINOIS

J. E. LAMAR

ABSTRACT

The seven southernmost counties of Illinois—Alexander, Hardin, Johnson, Massac, Pope, Pulaski, and Union—contain a wide variety of limestones of Paleozoic age. Their distribution and chemical and physical character are described herein as they relate to the potential uses of the stone, with particular attention paid to their suitability for making portland cement.

The selection and evaluation of quarry sites are discussed, as are the principal uses of limestone. Limestone resources are presented by geological formation and by county. County maps show the distribution and general character of the various limestone formations. The significance of the clay and shale resources to portland cement making is briefly discussed. Results of 118 chemical analyses and 40 physical tests of limestones and of 58 chemical analyses of shales and clays are given.

INTRODUCTION

This report covers the limestone resources of Alexander, Union, Johnson, Pope, Hardin, Pulaski, and Massac Counties, which are here referred to collectively as extreme southern Illinois (fig. 1). The area contains a diversity of limestones suitable for a variety of uses. These rocks are dominantly of the calcitic type and the term "limestone" is used with this meaning throughout the report.

The report brings together data from various published sources, and adds much new analytical information. In particular, data have been taken from Weller (1920), Lamar (1925), Weller et al. (1939), Weller and Ekblaw (1940), and Weller et al. (1952). The many new chemical analyses are the work of the Illinois State Geological Survey's Section of Analytical Chemistry.

Thanks are also due to D. L. Biggs, C. B. Claypool, J. Dyni, C. E. Dutton, R. M. Grogan, D. L. Hutcheson, M. E. Ostrom, R. S. Shrode, H. B. Willman, and other members of the Illinois State Geological Survey staff who have had a part in the field work and sampling relating to the new data contained in this report. The information has been collected by many persons over the course of many years.

Members of the portland cement industry made valuable contributions to the report by providing data on specifications of raw materials for cement. Horace C. Krause, president of Columbia Quarry Company, furnished information regarding the results of drilling an outcrop of Ste. Genevieve Limestone in Post Creek cutoff in eastern Pulaski County, and R. C. Allen, of the Adam Groth Stone Company, advised regarding the probable decorative value of certain limestones.

Scope and Nature of Report

Extreme southern Illinois contains many outcrops of limestone. Some of them change but little from year to year, a few are increased in size as streams or rain wash away overlying earth materials, others are reduced in extent as parts of them become covered by earth or sand, and some outcrops are completely buried.

Because of their number, it is not practical to describe all the limestone outcrops in extreme southern Illinois, nor is it feasible to map the outcrops individually. Instead, information is given about the general character and possible uses of each limestone formation so that, when the name of the limestone formation to which any specific outcrop belongs (pls. 1-6) is

FIG. 1.—Map showing counties covered by report.

known, the probable general usefulness of most outcrops can be evaluated.

Many reports that deal with the geology and the limestone resources of extreme southern Illinois (see references) have given details regarding outcrops, described the character and distribution of the various limestone formations, and are accompanied by maps. The bulk of such published material makes it impractical to repeat in this report all the available data regarding limestones.

It is evident that all the limestone outcrops in extreme southern Illinois are not now equal in possible commercial importance. In some, the available limestone is too thin or the overburden of earth or bedrock strata is too thick to make quarrying economically feasible. Others are too far from suitable transportation or are in areas where the market for stone products will not support a quarry. Still others are in areas where existing quarries are supplying limestone products. Thus, only certain limestone deposits are likely to have commercial significance now because of their size, thickness, composition, workability, availability to transportation and to unsupplied markets of permanent character or of temporary nature, such as road building in the general vicinity.

This report therefore 1) assembles all pre-existing data and much new chemical and physical analytical data on the limestones into a single report, 2) shows by county maps the distribution of the various formations consisting of or containing limestone, 3) discusses briefly the character of these formations and their possible uses, and 4) summarizes the limestone resources of each county.

Evaluation of Resources of Specific Properties

From the county maps it is possible to determine whether a formation consisting of, or containing, limestone probably underlies any given property and to determine the name of the formation. The description of that formation, the chemical and physical tests of samples from it, and the discussion of its uses will give an idea of the limestone's general character and possible uses. The further evaluation of the workability of the deposit, its thickness, availability of transportation, and possible market must then be judged on the basis of local characteristics of the deposit and its location.

Sites for Large Quarries

In the development of large quarries that do not depend solely on a local market for the disposal of their products, many matters other than the mere existence of a limestone deposit are important. The deposit generally must be within a few miles of either rail or water transportation that gives a suitable access to the market where the stone or stone product is to be sold. Adequate electric power also is often a requisite.

The limestone deposit must generally be capable of supplying a large tonnage of suitable stone for a long time. The deposit must therefore generally contain millions of tons of stone that is reasonably uniform in composition and thickness. If the limestone is to be quarried from an open pit, the overburden must not be too thick to be economically removed. If it is to be mined underground, the deposit must have a suitable mine roof and floor.

The selection of a site for a large limestone quarry involves, therefore, the balancing of many factors, some of which vary with changes in markets and in quarrying procedures. The proving up of a site meeting these requirements involves more than mere inspection and testing of outcrops and is likely to include extensive test drilling followed by a careful study of the cores or cuttings produced and the analysis of many samples.

The data in this report can be applied to the problem of selecting sites for large-scale quarries or mines after transportation requirements and markets to be served have limited the choice of areas where a quarry or mine could be operated economically. The data on the county maps will show areas where limestone is available, and the discussion and analytical data regarding the limestone formations existing therein will permit a reasonable evaluation of limestone resources.

The test drilling, sampling, and analytical work involved in evaluating sites selected to meet the requirements of any individual concern or operator are beyond the scope of this report. Such matters commonly are handled by the concern or operator, who uses the exploratory and test procedures that have proved most suitable for determining the character and workability of a deposit for the particular uses he proposes for it.

Limestone Quarrying Industry

Twelve quarries in extreme southern Illinois are producing crushed stone for various purposes. They are listed below, together with the name of a nearby town and the formation being quarried:

Hardin County

Denny and Simpson Stone Co., Elizabethtown—Ste. Genevieve Formation

Columbia Quarry Co., Shetlerville—Ste. Genevieve Formation

Okerson Quarry Co., Cave in Rock—Ste. Genevieve Formation

Rigsby and Barnard, Cave in Rock—Ste. Genevieve Formation

Johnson County

Charles Stone Co., Whitehill—Ste. Genevieve Formation

Johnson County Stone, Inc., Buncombe—Kinkaid Formation

Southern Illinois Stone Co., Buncombe—Kinkaid Formation

Massac County

Columbia Quarry Co., Mermet — Ste. Genevieve Formation

Pulaski County

Columbia Quarry Co., Ullin—Warsaw-Salem Limestone

Union County

Anna Quarries, Inc., Anna—Ste. Genevieve Formation

Columbia Quarry Co., Lick Creek—Kinkaid Formation

Jonesboro Stone Co., Jonesboro — Warsaw-Salem Limestone

In addition to those named above, the Lutz Marble Company of Anna and the Agatan Stone and Machinery Company of Dongola produce marble, dimension stone, and other varieties of building stone from the Warsaw-Salem Limestone.

Table 1.—Succession of Limestone-bearing Formations and Related Strata

Pleistocene Series
- Loess; alluvial clay and silt

Paleocene Series
- Porters Creek Clay

. . . .

Cretaceous System

. . . .

- Clay

Pennsylvanian System
- Sandstone and shale

Mississippian System
- Kinkaid Formation (limestone and shale)

. . . .

- Clore Formation (shale and limestone)

. . . .

- Menard Formation (limestone and shale)

. . . .

- Vienna Formation (limestone and shale)
- Tar Springs Formation (sandstone and shale)
- Glen Dean Formation (limestone and shale)

. . . .

- Golconda Formation (limestone and shale)

. . . .

- Paint Creek Formation (shale and limestone)

. . . .

- Renault Formation (limestone and shale)
- Ste. Genevieve Formation (limestone)
  - Hoffner Member
  - Levias Member
  - Rosiclare Member
  - Fredonia Member
- St. Louis Limestone
- Warsaw-Salem Limestone
- Burlington-Keokuk Formation (limestone and chert)
- Springville Shale

Devonian System
- New Albany Shale
- Alto Formation (limestone and shale)
- Lingle Limestone
- Grand Tower Limestone

. . . .

- Clear Creek Formation (chert and limestone)
- Backbone Limestone
- Bailey Limestone

Silurian System
- Bainbridge Group (limestone and shale)
  - Moccasin Springs Formation (shale and limestone)
  - St. Clair Limestone
- Sexton Creek Limestone
- Edgewood Limestone
- Girardeau Limestone
- Orchard Creek Shale

Ordovician System

. . . .

- Kimmswick Limestone

GEOLOGY OF SOUTHERN ILLINOIS LIMESTONES

Exposed Limestone-Bearing Formations

More than 25 formations containing limestone compose a part of the bedrock of extreme southern Illinois. Between some of these formations lie sandstone or shale formations. The names of the formations that contain limestone are given at left in order of their geological age (the youngest are at the top), together with the names of the great systems of rocks into which the formations have been classified. The names of other formations, chiefly clay or shale, which are mentioned in the report also are included. A dotted line between two formations indicates the presence of a sandstone, shale, or chert formation whose identity is not significant in this report.

As shown in table 1, the youngest and uppermost of the limestone-bearing formations in extreme southern Illinois is the Kinkaid Formation. Lying above this formation, and geographically to the north of it, is a great thickness of sandstone and shale of Pennsylvanian age that is not known to include significant thicknesses of limestone in the counties involved in this report. Thus, the Kinkaid Formation is the northernmost source of limestone in the area of this report.

Structure

The structure or lay of the bedrock strata in extreme southern Illinois varies greatly. In many places the beds lower gently or dip to the northeast at a rate of a few hundred feet to the mile. This regional dip is interrupted at many places by faults where large masses of the bedrock have been displaced along a vertical or nearly vertical plane, moving up on one side and down on the other. Faults are especially numerous in Hardin and Pope Counties but also occur in other counties.

In some places the bedrock strata have been arched into folds of various sizes. This is particularly true in Hardin County where the rocks have been thrust up to form Hicks Dome, which centers about

eight miles north and a little west of Rosiclare. Another upfold extends roughly eastward from a point in the Mississippi River bluffs about one mile south of Thebes.

Limestone deposits that lie nearly flat are generally more easily quarried than those in which the strata have been considerably folded. Faulted deposits also offer problems because desirable ledges of limestone may be cut off by the faults or because the deposits may have open or clay-filled joints that have been produced by the action of groundwater along the faults and associated fractures and crevices.

Character of Surface of Limestone Deposits

The character of the surface of limestone deposits is significant in connection with quarrying. Where the surface is irregular, it is more difficult to strip off the overburden and considerable stone may have to be removed and wasted before quarrying is begun.

Where the limestone deposits of extreme southern Illinois are not overlain by other bedrock deposits, they generally have an overburden of clay, silt, sand, or gravel resting on them. Below the overburden the top of the limestone is commonly irregular, in places extremely so. In some areas the unevenness of the surface was produced by the carving action of running water that came from rains and snows during many thousands of years. In other places water slowly percolated through overlying materials and unevenly dissolved some of the limestone in the upper parts of the limestone deposits, leaving a surface characterized by ridges and pinnacles of the remaining rock.

In some areas sink holes are abundant and probably indicate that the bedrock surface is irregular and that the limestone possibly may contain channels and open crevices.

The areas most likely to have nearly smooth-topped limestone deposits probably are broad upland flats free from sink holes, or the valleys of some of the smaller present streams. The upland flats are likely to have a comparatively heavy overburden. The valley flats of the smaller streams have less overburden, but areas are relatively small and may be subject to flooding.

Overburden

The overburden on the limestone deposits of extreme southern Illinois may be of one or both of two general types: bedrock strata and/or unconsolidated materials. In general, limestone deposits that have a heavy bedrock overburden are worked by underground mining rather than by open pit. However, where the bedrock overburden is relatively thin, soft shale or sandstone that can be stripped without difficulty, open pit mining may be possible. The bedrock overburden on the limestone deposits of extreme southern Illinois is principally shale, sandstone, or shale interbedded with sandstone or limestone.

The surficial material on the uplands of most of extreme southern Illinois is a brown, silty clay or clayey silt called "loess" which varies from a few to 50 or more feet thick. It is generally thickest in those upland areas adjacent to the flats of major rivers.

In some parts of extreme southern Illinois clay, silt, and sand and/or gravel may underlie the loess and constitute a further overburden on limestone deposits. The material immediately above many limestone deposits is a reddish, sticky clay that is a residue left as a result of the solution of the upper part of the limestone deposit. In some places the clay contains fragments or masses of chert that originally were a part of the limestone that was dissolved and from which the clay came. The presence of reddish clay on top of a limestone deposit is an indication that the surface of the deposit may be irregular.

Because the removal of overburden from a limestone deposit increases the cost of quarrying, it is desirable to choose deposits with a comparatively thin overburden for open-pit development. The kind of overburden, the ease with which it can be moved, and the difficulty with which the

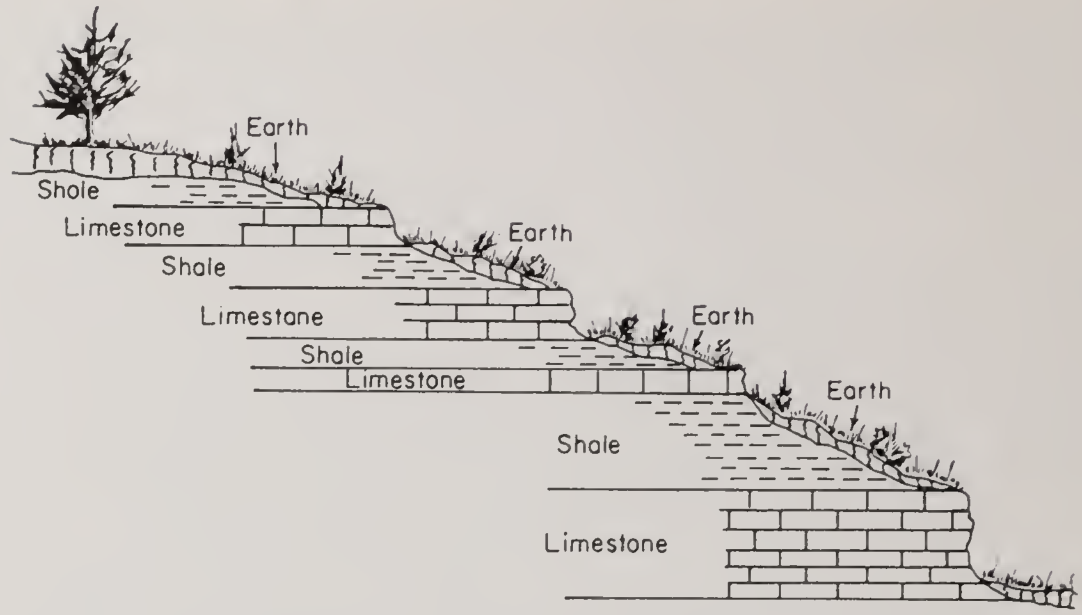


FIG. 2.—Cross section of a hillside underlain by interbedded limestone and shale. The limestone crops out in "steps" or ledges; the shale does not crop out.

upper surface of the limestone deposit can be cleaned of its overburden are all important. To the cost of removing overburden must be added the cost of disposing of it. Therefore areas convenient for dumping overburden are desirable adjacent to a limestone deposit.

Outcrops of Interbedded Limestone and Shale

A number of the formations subsequently described consist of alternating strata of limestone and shale. Many outcrops of such formations occur in hill slopes that are partly covered by soil and vegetation. Under such conditions the limestone commonly crops out as "steps" or ledges, but the shale beds are covered by earth and vegetation and generally are not easily seen without careful search, if at all. The situation is illustrated in figure 2.

It is sometimes assumed that the covered areas between the successive limestone steps or ledges also are underlain by limestone. As figure 2 shows, this may well be erroneous and may lead to the conclusion that the limestone is much thicker than it is, thus giving false ideas as to the quarryability of the deposit. The thickness of the limestone in outcrops, like that pictured in figure 2, should not be taken for granted, and covered areas should be thoroughly explored to determine the nature of the rock composing them.

TERMS USED IN DESCRIBING LIMESTONES

There are two principal types of limestones: (1) those made up principally of calcite and thus sometimes referred to as calcitic limestones, or more commonly just limestone, and (2) those made up largely of dolomite and usually called dolomite. No dolomite deposits of commercial size are known to exist in extreme southern Illinois.

A number of terms are here employed to describe the appearance of limestones and limestone deposits. The term "grain" refers to the size of the particles or crystals composing a limestone; thus a coarse-grained limestone would be one composed of coarse particles or crystals. A description of the composition of a limestone may involve the term "sandy" or "clayey" to indicate the presence of considerable amounts of sand or clay. *Shaly* limestone refers to thin-bedded limestone generally having beds or bands of shale or clay interlayered with the limestone. *Cherty* limestone contains nodules or beds of chert, also called flint. Chert is abrasive to stone-crushing equipment.

If a chemical analysis of a limestone has been made, the limestone's composition may be referred to on the basis of its calcium carbonate content. The term "high-calcium limestone" is often used to describe

limestones whose calcium carbonate content exceeds 95 percent. It is believed, however, that many high-calcium limestones used commercially contain more than 97 percent calcium carbonate.

Some limestones consist of many small, rounded particles that characteristically have a center surrounded by one or more concentric layers. The rounded particles are known as oolite grains and a limestone composed of these grains is called an oolite. In connection with certain uses it is customary to refer to limestones as two general types: oolitic and crystalline. Under such usage certain limestones that are made up of rounded grains, even though they are not oolite grains, are nonetheless in some cases referred to as oolites or oolitic limestones.

REQUIREMENTS OF LIMESTONES FOR VARIOUS USES

Specifications for limestone vary according to its different uses and a variety of tests is involved in determining whether the stone meets these specifications. Both the specifications and methods of testing change from time to time and are too numerous to discuss in detail. However, this section of the report points out briefly some of the more important properties of limestones, especially southern Illinois limestones, that affect their use. The size of the stone for various uses is mentioned only when size is not influenced by a crushing procedure involved in preparing the stone for market because the crushed sizes are controllable and are not a primary property of the natural deposit.

Because specifications vary according to the demands of different users, it is important in attempting to market a stone for a particular use to obtain the specifications of the consumers who are most likely to use the stone.

USES OF LIMESTONE

Limestone has many uses (Lamar and Willman, 1938). For convenience they are classified roughly as "physical uses" and "chemical uses," even though there is often a relationship between the physical and chemical characteristics of limestones.

Physical uses include those for which the physical properties of a limestone are of primary importance and for which specifications for the physical properties of the limestone commonly exist. Weather resistance, color, hardness, wear resistance, soundness, water absorption, and weight per cubic foot are the properties generally involved, singly or in combination.

Chemical uses are those in which the chemical composition of a limestone is of primary importance and limestone used for chemical purposes must pass certain specifications relating to the percentage of calcium carbonate, magnesium carbonate, iron oxide, silica, or other compounds present.

The specifications for some uses involve both the physical character and chemical composition of limestone. Uses of this sort are treated under the heading of chemical uses because the physical property most commonly involved is the size of the pieces of stone. Size is not commonly a characteristic of the natural stone but rather is controllable during crushing.

Below are listed the major and some minor uses of limestone for which production was reported in 1956 (modified from Minerals Yearbook, 1956). A few of the uses involve both chemical and physical properties to such a degree that they might be placed in either category. Uses known or believed to have a national production valued at more than $500,000 are starred (*).

Physical Uses. — Riprap*; building stone*; decorative stone*; aggregate for portland cement concrete*; road stone*; filter beds of sewage disposal plants; limestone sand*; road base; stucco, terrazzo chips and artificial stone; fill materials; "blacktop" chips and aggregate for bituminous concrete*; and railroad ballast*.

Chemical Uses.—Cement*; lime*; agricultural limestone*; alkali manufacture*; carbide manufacture*; rock dust for coal mines*; filler for asphalt*, fertilizer and

other purposes*; fluxing stone*; glass manufacturing*; limestone whiting*; mineral food*; rock wool; paper manufacture*; poultry grit*; sugar refining*; acid neutralization; carbon dioxide manufacture; chemicals*; and lesser uses.

It is not feasible here to detail the requirements of limestone for all the uses mentioned above, but some of the more important chemical or physical characteristics necessary for most of them are given below.

Requirements for Physical Uses

Limestone for concrete aggregate, railroad ballast, chips for blacktop roads, chips for stucco, roofing granules, terrazzo and artificial stone, road stone, limestone sand, and road base should be sound, hard stone. Soft or lightweight stone, or stone with interbedded shale is not likely to be satisfactory. Stone for some of these uses must pass a wear-resistance test and five cycles of the sodium sulfate soundness test, or an equivalent test. A uniform and desirable color, such as white, brown, pink, or black, is often demanded in limestone chips used for stucco, terrazzo, and artificial stone. Hardness, durability, ability to take a good polish, and low liquid absorption also are desirable in terrazzo chips (Bowen, 1957). Stone for filter beds for sewage disposal plants must pass 20 cycles of the sodium sulfate soundness test, or an equivalent test. Hard, nonporous, heavy southern Illinois limestones are more likely to pass this test than limestones that do not have these characteristics.

Riprap is used to protect embankments and the shores of rivers and lakes from destruction and consists of large pieces of stone, all or some of whose dimensions commonly are measured in feet. A medium- or thick-bedded deposit is required to supply such limestone. It should have good resistance to weather and to splitting and cracking.

Building stone—including rubble, veneering stone, flagstone, and ashlar—and other types of cut stone should have a pleasing color and good weather resistance. Thin- or medium-bedded deposits are most easily worked for veneering or flagstone, and generally for rubble stone. The performance of stone in old structures such as walls, foundations, or chimneys, is in general a good indication of how the stone from a particular quarry will resist weathering and retain its color.

Decorative stone includes marble and is used especially for interior decoration. A thick-bedded stone, commonly in layers 4 or more feet thick, with a pleasing color and textural pattern is desirable.

Fill material may be waste limestone from various sources and is used to make road fills and the like.

Roofing granules, used for coating roofs, should be hard and have good weather resistance.

Requirements for Chemical Uses

Lime.—The calcitic limestone used in Illinois for making lime is all high-calcium limestone.

Agricultural Limestone.—The calcium carbonate equivalent (CCE), or neutralizing value, of a limestone in large measure governs its use as agricultural limestone (agstone). Most Illinois limestones used for agricultural limestone have a CCE of more than 90 percent, but lower-testing limestones are used where purer stones are not available, or where the lower-testing stones are more economical to use. Agricultural limestone is generally crushed to particles for the most part smaller than 1/10 inch. Chert is undesirable in limestone crushed for agstone because the chert not only is abrasive to crushing equipment but lowers the calcium carbonate equivalent.

Alkali Manufacture. — High-calcium limestone with a low silica content is required for alkali manufacture.

Carbide Manufacture. — High-calcium limestone low in silica and magnesium carbonate is used for carbide manufacture. Specifications vary with different users. However, a combination of data from several sources suggests that carbide stone probably should contain less than the following approximate amounts of the compounds listed: magnesia (MgO) 1.25 per-

cent, silica (SiO_2) 1.2 percent, phosphorus (P) .01 percent, and iron oxide (Fe_2O_3) and alumina (Al_2O_3) .75 percent. An oolitic stone is preferred by some users.

Rock Dust.—Used in coal mines to control mine explosions, rock dust should be a pulverized, light-colored limestone containing not more than 5 percent free silica nor more than 5 percent combustible material (Forbes and Owings, 1947).

Filler for Asphalt, Fertilizer, and Other Purposes.—Size and chemical specifications vary for limestone used as asphalt filler, fertilizer, and such purposes, although for many of these uses a pulverized high-calcium limestone is employed.

Glass Making.—High-calcium limestone is used in glass making. Iron oxide in the stone should not exceed 0.3 percent for most glass, and for flint glass it should not be more than 0.03 percent. Organic matter must be limited to about 0.3 percent (Goldbeck, 1949).

Limestone Whiting.—Limestone whiting, a pulverized product of high whiteness, usually is made from high-calcium limestone.

Mineral Feed.—Pulverized high-calcium limestone is used for mineral feed.

Rock Wool.—Only a small tonnage of stone is used in the United States for rock wool manufacture. It may be an impure limestone, possibly dolomitic, having a carbon dioxide content between 20 and 30 percent. It is generally used in coarse pieces. Limestones or dolomites of various compositions are used in some places to modify the composition of the slag now commonly employed to make rock wool.

Paper.—High-calcium limestone, generally in coarse pieces, is used in paper making. Carbonaceous material and pyrite probably are undesirable.

Flux for Iron and Steel Making.—High-calcium limestone used for flux generally is low in silica and for open-hearth flux a low sulfur and phosphorus content is necessary.

Sugar Refining.—A high-calcium limestone having not more than 1 percent silica and less than 4 percent magnesium carbonate is used in sugar refining. It should be in coarse pieces (Ballou, 1951).

Poultry Grit.—Small chips of high-calcium limestone are used for poultry grit. A light color probably is desirable. Fluorine content should be low.

Acid Neutralization, Carbon Dioxide Manufacture, and Manufacture of Chemicals.—High-calcium limestone is employed for these purposes.

Portland Cement.—The manufacture of portland cement is complex, and variations in equipment and procedures allow a certain latitude in the details of the specifications for the raw materials used. The cement commonly is made from a mixture of limestone and clay or shale, less commonly from cement rock or other materials. The proportion of limestone and shale or clay in the raw mix varies according to the chemical composition of each, but when comparatively pure limestone is used the mix consists roughly of 4 parts by weight of limestone to 1 part of clay or shale. Sandstone may be substituted for some of the clay or shale if they are too high in alumina. A major requirement for the raw mix for portland cement is that its magnesia content not exceed approximately 3.2 percent and it is generally desirable that the amount be below this figure. As limestone is the principal component of the raw mix, it is particularly important that its magnesia content be less than 3.2 percent.

An important characteristic of the clay or shale used in the raw mix for making cement is the ratio between the amount of silica present and total amount of iron and alumina. This is called the *silica ratio* and should be roughly between 2.0 and 3.0 but may vary as a function of the raw materials and the length and diameter of the kilns used in cement making.

The alkali content of portland cement also is important. Because of variations in the manufacturing process that affect the alkali content of the finished cement, it is impossible to specify exact limits for the alkali content of the materials composing

the raw mix. However, in general it is probably desirable that the raw mix should not contain more than .6 percent alkali content expressed as Na_2O equivalent. Some chemical analyses report Na_2O and K_2O together as Na_2O. The percentage figure so given is the Na_2O equivalent. Other analyses report Na_2O and K_2O separately. The Na_2O equivalent in this case is a total of the percentage of Na_2O plus the percentage of K_2O multiplied by 0.66.

Other requirements for the cement raw mix are that its sulfur content be low and its P_2O_5 content be less than 0.5 percent.

Chert nodules, siderite nodules, and other hard masses in limestone, shale, and clay are usually undesirable because they require more than normal grinding to reduce them to the size necessary for the cement raw mix.

It is evident, then, that not all limestones, clays, and shales are suitable for making portland cement and that a reasonable constancy of composition is advantageous in the deposits from which the raw materials are obtained. The fact that a balance must be maintained between the relative amounts of limestone and shale or clay used is a critical matter in evaluating the possibilities of deposits consisting of interbedded limestone and shale. Too great an amount of either component in the deposit will require the disposal of excess material. As the thickness and composition of the shale and limestone beds in such deposits commonly vary laterally and vertically, careful testing of deposits is desirable. The variability of the interbedded deposits may favor the use of separate limestone and shale or clay deposits of more uniform character.

In the tables accompanying this report, many analyses of limestone, clay, and shale are given. It is not feasible to evaluate each analysis with respect to the usability of the stone it represents or to list possible combinations of the samples as raw materials for cement. Instead, general statements are made to indicate possible uses for the materials of the various rock units discussed. However, the usual major requirements for cement raw materials, as given, permit a preliminary evaluation of individual samples and combinations.

Because of the importance of variations in the chemical composition of cement raw materials, it is obvious that a few analyses of samples from outcrops cannot establish the suitability of a given deposit and that a considerable program of test drilling and analysis is involved in determining the usefulness of a deposit from the standpoint of raw materials alone.

White portland cement requires raw materials low in iron. The Fe_2O_3 in the limestone used probably should be less than 0.1 percent and the Fe_2O_3 in the clay or shale less than 0.75 percent, although this requirement may be waived if the clay or shale is white after firing.

The term "cement rock," used in connection with raw materials for portland cement production, is applied to argillaceous (clayey) limestone low in magnesia that is the principal constituent of a portland cement raw mix and requires only small additions of other clayey or calcareous materials to adjust the composition of the mix to the exacting requirements of modern specifications. Clay or shale are the most commonly added sources of silica, alumina and iron oxide, and "pure" limestone is the common source of calcium carbonate. Other additives may be silica, usually as sand, alumina, as diaspore and bauxite, and iron, as pyrite or iron-bearing slag.

The term "cement rock" was applied originally to impure limestone or dolomite containing silica or alumina in such amounts that it could be used as a single raw material for manufacture of natural cement. Natural cement was widely used before the development of portland cement, but present production is small compared to that of portland cement.

RESULTS OF TESTS

At the end of this report are several tables. Table 3 gives the chemical analyses of limestones arranged by formations; table

4 shows chemical analyses of clays and shales arranged by formation; table 5 lists chemical analyses of limestone, clays, and shales arranged by counties; table 6 gives results of recent physical tests on limestones; and table 7 shows results of earlier physical tests on limestones.

Chemical Analyses

The chemical analyses in tables 3 to 5 include many new analyses as well as those compiled from older publications. The tables contain all the available analyses of southern Illinois limestones, clays, and shales, except for a few published analyses that were omitted because they gave indefinite locations or otherwise imperfect data.

In most analyses the figures for $CaCO_3$ and $MgCO_3$ in the limestone analyses were obtained by the common procedure of multiplying the CaO and MgO figures by suitable factors. Some analyses reported $CaCO_3$ and $MgCO_3$ but not CaO and MgO. Figures for the latter compounds have been calculated by multiplying the $CaCO_3$ and $MgCO_3$ figures by suitable factors.

Analyses of several sets of samples from operating quarries, representing stone in various units of the quarry faces, are given in tables 3 and 5. Their vertical position is relative to the base or floor of the quarry at the time the sample was taken. The date of sampling is given. These samples were not commercially prepared grades of stone and represent only the stone exposed in the quarry at the time and places sampled.

Physical Tests

Table 6 gives the results of recent physical tests made on samples to obtain data on those characteristics important to the use of the stone for roads or concrete. The tests were kindly made by the Illinois State Division of Highways, Bureau of Materials, Springfield. The results of physical tests given in table 7 were compiled from published sources. These tests also give data on the value of the samples tested as road material and concrete aggregate.

DISCUSSION OF RESOURCES

The discussion of limestone resources includes county maps showing resources, descriptions of the various limestone or limestone-bearing formations whose names appear on the resources maps, and a summary of resources and use possibilities arranged by counties. The discussion by formations and the tables of analyses serve to enlarge upon the county data.

In connection with many of the formations, general descriptions of outcrops are given. Further details regarding the location and character of many of the outcrops are given in tables 3 and 5 in connection with the chemical analyses, and many of the outcrops described there constitute some of the better ones seen.

Resources by Geological Formations

Extreme southern Illinois contains 23 limestone or limestone-bearing formations whose names and succession, one above the other, are indicated in table 1. The areas underlain by these formations are shown on plates 1-6. The formations are discussed in alphabetical order.

Alto Formation

See Lingle Limestone and Alto Formation.

Backbone Limestone

Distribution and Character

The Backbone Limestone crops out in northwestern Union County (pl. 6) and is best exposed in the bluffs of Hutchins Creek from sec. 1, southwestward to sec. 25, T. 11 S., R. 3 W. Although the formation is mapped as occurring near Wolf Lake, it is not well exposed there and may be thin or highly cherty.

The limestone is light gray or gray, crystalline, and occurs in thick beds. Some of it has an almost marble-like texture. Stylolites are locally abundant. Along Hutchins Creek, 30 or more feet of chert-free limestone is present near the base of the formation; otherwise the formation contains chert.

The Backbone Limestone as now defined is a chert-free limestone (Collinson and Schwalb, 1955) about 60 feet thick. As used by Weller and Ekblaw (1940) in the maps modified for this report the formation includes certain cherty beds and may be as much as 200 feet thick.

Results of Tests

Chemical analyses of the Backbone Limestone are given in table 3. Sample NF 444, from 40 feet of chert-free Backbone Limestone along Hutchins Creek, contains about 1 percent impurities and is a high-calcium limestone. Another sample, NF 536, representing 29 feet of stone and taken near Rattlesnake Ferry in Jackson County about 1½ miles north of the Union County line, is similar.

Uses

The chert-free limestone of the Backbone Formation may be suitable for many of the uses of high-calcium limestone previously discussed. The chemical analyses suggest that it probably is of suitable composition for use as a part of a raw mix for making portland cement. It would probably be acceptable for concrete aggregate or road material, railroad ballast, chips for bituminous roads, riprap, and rubble. The limestone takes a good polish and some of it has a pleasing cloudy appearance when polished. Thus it may be of interest as a marble for interior decoration. It probably would be a satisfactory building stone for exterior purposes unless the stylolites in the stone adversely affect its weather resistance.

Bailey Limestone*

Distribution and Character

The Bailey Limestone crops out prominently in the bluffs of the Mississippi River, especially from Wolf Lake northward to the north line of Union County and from a point a few miles north of Reynoldsville southward to Gale in Alexander County (pls. 1 and 6). It also underlies a considerable upland area in Alexander County. Many good outcrops occur in the river bluffs east of Reynoldsville, east of Aldridge, and at other places.

The formation consists of fine-grained, siliceous limestone, mostly in beds half an inch to 5 inches thick, many of which contain chert nodules. Lenticular beds of chert also are present. The basal beds of the formation are greenish or gray shale that grades into the shale of the upper part of the underlying Bainbridge Group.

The exact thickness of the Bailey Limestone is not known; the maximum observed thickness was 130 feet but the total thickness may be between 300 and 400 feet.

Results of Tests

Chemical analyses of the Bailey Limestone are given in table 3, Samples NF 70 and NF 91, NF 92, NF 93, NF 94, NF 530, and La 7. Locations of the outcrops sampled and places where the formation is well exposed also are given in the tables.

Uses

The Bailey Limestone is highly siliceous; present uses for it are few. Presumably it could be crushed for road rock, but the chert it contains is likely to be abrasive to crushing machinery. The high silica content of this limestone eliminates it from most of the common uses of limestone wherein chemical composition is important. Samples of the formation have been found experimentally to be suitable for making rock wool (Fryling, *in* Lamar et al., 1934). However, only small tonnages of limestone are used for making rock wool at the present time, the principal raw material being slag.

Bainbridge Group

The Bainbridge Group is found in northwestern Alexander and southwestern Union Counties, and its distribution is shown in plates 1 and 6, where it is mapped together with the Sexton Creek Formation. The Bainbridge is now considered to be composed of two formations, a lower limestone unit called the St. Clair Formation and an upper limestone and shale unit

* Weller and Ekblaw (1940) recognized the Bailey Limestone as distinct from an overlying chert unit called the Grassy Knob Chert. Present usage (Workman, *in* Weller et al., 1952) eliminates the name Grassy Knob, and both the limestone and chert together are called the Bailey Formation. The resources maps accompanying this report are based on the older usage.

called the Moccasin Springs Formation. These are described subsequently in their alphabetical position.

Burlington-Keokuk Formation

The Burlington-Keokuk Formation and its basal unit, the Hartline Chert Member, constitute the lower part of the Mississippian strata in Alexander, Pulaski, and Union Counties. (See also "Warsaw-Salem Limestone.") The Burlington-Keokuk is largely chert or cherty limestone (pls. 1, 4-B, and 6). Sample NF 534, table 3, was taken from 22½ feet of such limestone west of Ullin. The chert in the limestone was excluded from the sample; however, the sample contained 15 percent silica. The chief use for the limestone parts of the Burlington-Keokuk Formation is likely to be for road rock or fill material. Results of physical tests on the limestone are given in table 7.

Krey (1922) estimates the thickness of the Burlington-Keokuk Formation, which he calls Osage, at 275 to 325 feet; Savage (1920b) gives the thickness of the Hartline Chert as 60 feet.

Burlington-Keokuk deposits crop out in scattered places in a limited area around Hicks Dome in Hardin County (pl. 2). The exposed rocks consist principally of chert. Probably the deeper unexposed strata are cherty, dark-colored limestone. The thickness may be as much as 550 feet. Too little is known about the formation to provide a basis for discussion of its uses.

Clear Creek Formation

The Clear Creek Formation underlies extensive areas in western Union County and in the uplands of northern Alexander County (pls. 1 and 6). South of State Highway 146, which extends westward from Jonesboro, the formation consists of chert. North of the highway it is chert, cherty limestone, and fine-grained siliceous limestone. Because of the presence of limestone in the Clear Creek Formation north of Route 146, this area is indicated by a pattern in plate 6.

The abundance of chert in the Clear Creek Formation and the impurities in most or all of the limestone composing parts of the formation limit its use. Conceivably some of the stone could be crushed for road rock or fill rock.

Clore Formation

The Clore Formation underlies a narrow, interrupted band across most of extreme southern Illinois (pls. 2, 3, 5, and 6). The formation is predominantly shale with interbedded lesser amounts of limestone that is commonly impure. In places, sandstone also is present. The limestone units vary in abundance from place to place, as does their thickness and character. The thickness of the formation ranges from about 20 to 40 feet in Union, Johnson, and Pope Counties, although locally it is 95 feet thick. In some places in Hardin County the formation is about 100 feet thick.

The Clore Formation and the overlying Degonia Sandstone and Kinkaid Formation are mapped together as a unit in plate 2, Hardin County. In a general way, deposits of the Clore Formation are most likely in the southern parts of the area shown to be underlain by the unit.

In the western part of southern Illinois the amount of limestone in the Clore Formation may be somewhat greater than the amount in the eastern part where the formation is principally shale, but the formation varies from one area to another. An idea of the general character of the formation in the western area is afforded by an outcrop that was exposed some years ago in a gully along the west line, NW¼ sec. 34, T. 11 S., R. 1 E., Union County. The 43 feet 1 inch of rock exposed consisted of seven limestone units ranging from 7 inches to 4 feet thick and totaling 13 feet 5 inches thick; four shale units ranging from 9 inches to 12 feet 9 inches thick and totaling 24 feet 11 inches thick; and two interbedded limestone and shale units totaling 4 feet 9 inches thick.

No samples were taken from the Clore for analysis. Probably some of the limestone beds could be used for road rock and possibly for agricultural limestone, but the chances of finding deposits that could

be worked commercially do not appear numerous. In general, the formation is believed to be too shaly to furnish a suitable balance of limestone and shale in the amounts used for making portland cement although locally conditions may be more favorable.

Devonian Limestone in Hardin County

An oval-shaped area in secs. 30 and 31, T. 11 S., R. 8 E., and sec. 25, T. 11 S., R. 7 E., Hardin County (pl. 2) is underlain by rocks of Devonian age. There are few outcrops. One outcrop of gray limestone is reported at the mouth of a large ravine in the NE¼ sec. 31. Elsewhere, outcrops of a mixture of chert and clay, probably a residuum from the weathering of limestone, suggest the original presence of cherty limestone. Too little can be deduced from the available outcrops of limestone to permit satisfactory discussion of its possible uses.

Edgewood Limestone

The Edgewood Limestone consists of oolitic limestone, earthy limestone, limestone conglomerate, and shale. Its thickness is not known to exceed about 12 feet and it is in general probably less. In many places it is absent. Deposits likely to be of present commercial importance are not known.

Fredonia Limestone Member

The Fredonia Limestone is a member of the Ste. Genevieve Formation and is discussed in connection with that formation.

Girardeau Limestone

Distribution and Character

The Girardeau Limestone crops out in a limited area around Thebes in Alexander County and east of Reynoldsville in southwestern Union County. The areas underlain by the formation are indicated in plates 1 and 6. The limestone has a maximum thickness of 30 to 40 feet but is thinner, or even absent, in some places. Two of the better outcrops of the formation occur near the middle of sec. 16, T. 13 S., R. 2 W., along Harrison Creek and at Rock Springs, southeast of Thebes at the center of the W½ sec. 21, T. 15 S., R. 3 W., where the limestone forms a series of steps and is prominently exposed in the bed of Orchard Creek.

The limestone is fine-grained, brittle, gray, and occurs in beds 1 to 8 inches thick but averaging about 4 inches thick. Thin clay or silt partings are present between many of the beds. A few scattered lenses or nodules of chert are present and are most prevalent in the upper part of the formation. The weathered surfaces of the limestone are light gray.

Overburden, heavy on most deposits, consists of other bedrock formations and/or clay, silt, and sand. The outcrop at Rock Springs has evoked considerable comment as a possible quarry site because the limestone is exposed for several hundred feet along the creek and underlies an area of several acres with an unconsolidated overburden probably less than 10 feet thick. The upper surface of the limestone deposit is considerably channeled, however, so that the thickness of the limestone probably varies and cannot accurately be predicted without test drilling.

Results of Tests

Table 3 gives the results of chemical analyses of two samples taken from different parts of the Rock Springs outcrop. Sample L 37 came from the limestone exposed in the bed and low banks of the creek; Sample NF 512 was taken from a vertical face of stone and from the bed of the creek at the west end of the outcrop. Probably both samples involve some of the same strata although L 37 includes higher beds than does NF 512.

Table 6 presents the results of a physical test on Sample NF 512.

Uses

The Girardeau sampled was not high-calcium limestone, judging from the two chemical analyses. The two samples have calcium carbonate equivalents of about 88 percent and 96 percent and, therefore, would be satisfactory agricultural limestones. The magnesium oxide content of the samples is at or near the permissible

maximum for portland cement raw materials and makes the quality of the stone uncertain for this purpose. The physical tests of Sample NF 512 indicate that it is acceptable for cement concrete and bituminous roads, road stone, railroad ballast, and the like. The thin-bedded character of the limestone may favor its use as flagstone, rubble, and veneer.

Glen Dean Formation

Distribution and Character

The Glen Dean Formation underlies a narrow area that extends, with local discontinuities, from northwestern Union County across southern Illinois into and across Hardin County (pls. 2, 3, 5, and 6). In Union County, where the formation is about 40 feet thick, it consists of varying amounts of limestone, much of it granular and fossiliferous, interbedded with gray shale, some of which is limy. Farther east in Johnson County, limestone predominates over shale in the upper part of the formation but shale predominates in the lower part. In an abandoned quarry about a mile south of Vienna, 28 feet of coarse-grained, fossiliferous limestone without interbedded shale is exposed. The limestone is overlain by sandstone and shale of the Tar Springs Formation.

The thickness of the Glen Dean in Johnson County and western Pope County probably is between 35 and 80 feet. In some places the formation is about 40 feet thick and consists entirely of shale.

In eastern Pope County and Hardin County the Glen Dean Formation is estimated to range between 50 and 70 feet thick. It consists of interbedded limestone and shale, the limestone probably most abundant in the upper part and shale most abundant in the lower part. The limestones vary in character. Some are granular, others are fine-grained; some beds are impure. Oolite and chert are present locally. The shales of the Glen Dean are gray to black and some of them are limy.

Results of Tests and Uses

Sample NF 554 L (table 3), taken from the abandoned quarry south of Vienna, contains roughly 93 percent carbonates. It was quarried for agricultural limestone, road rock, and possibly for concrete aggregate. Samples NF 554 S (table 5) comes from the lower six feet of shale in a 20-foot exposure of shale and sandstone overlying the limestone. The shale is considered to be part of the Tar Springs Formation. The magnesium oxide content of the shale and limestone samples is within the limits for cement-making materials.

The commercial use of the Glen Dean as a source of limestone requires the location of deposits that are sufficiently free of shale and thick enough to be workable and are likewise of satisfactory chemical and/or physical character. Exposures of the Glen Dean are generally poor so that the detailed nature of the formation is known at only a few places, but it is possible that agricultural limestone, road rock, aggregate for concrete and bituminous roads, and cement-making materials might be produced from the formation if adequately thick deposits of suitable stone can be found.

Golconda Formation

Distribution and Character

The Golconda Formation occurs in parts of northwestern Union County, from whence a narrow band extends southeastward to and across Johnson County. In western Pope County it is present at scattered places, but in eastern Pope County and in Hardin County it underlies considerable areas (pls. 2, 3, 5, and 6).

In western Union County the formation is gray or buff limestone interbedded with shale, the limestone predominating. A few beds of oolitic limestone are present. The maximum thickness of the formation is about 60 feet.

Sample NF 515 L represents 7 feet 9 inches of limestone in a 12-foot 4-inch exposure of limestone and shale near Mountain Glen. NF 515 S was taken from 4 feet 8 inches of shale in the outcrop.

In eastern Union County the formation is limestone and shale interbedded. The limestone is granular and in beds 8 to 36 inches thick. A few strata are oolitic. An

outcrop in a gully in the SW¼ NW¼ sec. 4, T. 12 S., R. 1 W., southeast of Cobden consisted of 22 feet of limestone in 3- to 6-foot units with which was interbedded 10 feet of shale in 4- to 6-foot units. The formation is about 80 feet thick. Another outcrop along Cypress Creek in sec. 2, T. 13 S., R. 1 E., consisted of 8½ feet of limestone in beds 3 to 14 inches thick interbedded with 41 feet of shale in beds 6 inches to 18 feet thick. Sample NF 535 L was taken from the limestone and Sample NF 535 S from the shale.

In Johnson, Pope, and Hardin Counties the Golconda is composed of limestone and shale but is more shaly in its middle portion and contains more limestone in its upper and lower portions. Some limestone layers are oolitic. The thickness of the formation ranges roughly from 40 to 150 feet but is generally between 100 and 145 feet.

The shale in the Golconda Formation is gray, black, or greenish and much of it is limy. In Hardin County some of the shale in the middle of the formation is sandy.

Results of Tests and Uses

Samples NF 535 L, W 308, W 319, and BU 20 (table 3) are limestone from the Golconda Formation and indicate that the purity of the limestone strata in the formation varies. Some of the limestone should be satisfactory as agricultural limestone and road rock. No samples were tested for concrete aggregate but some beds may be suitable for this purpose. Because of the presence of interbedded shale throughout much of the Golconda Formation, a major problem in connection with its development as a source of crushed stone is that of finding a sufficient thickness of shale-free, or largely shale-free, stone to justify quarrying.

The magnesium oxide content of the limestone samples is within the limits allowable for portland cement making, as is the magnesium oxide content for four samples of Golconda Formation shale, Samples NF 535 S, BU 21, BU 22, and BU 23 (table 4). The lateral variation in the thickness and composition of the limestone and shale units in the Golconda would require careful attention to maintain a uniform mixture of raw material for cement making. Deposits also should be investigated to assure the presence of a suitable balance between the amounts of limestone and shale present.

Grand Tower Limestone

Distribution and Character

The Grand Tower Limestone occurs in a narrow zone extending northward from the vicinity of Jonesboro in Union County. Two other areas of the limestone also occur in western Union County. Its distribution is shown, together with a generally thin sandstone formation that underlies it, in plate 6. The limestone varies from light to dark gray, fine- to coarse-grained. The basal part of the formation contains sand and some of the upper strata contain clay. The maximum thickness of the formation is not known but may be about 100 feet.

As much as 30 feet of the sandy lower limestone of the Grand Tower has been observed (Savage, 1920a) in the bluff of the Mississippi River in the NE¼ sec. 19, T. 12 S., R. 2 W., east of Ware, together with 28 feet of the higher, light gray, crystalline part of the Grand Tower Limestone. Another good outcrop has been noted in the SW¼ NW¼ sec. 1, T. 11 S., R. 3 W. In the NW¼ NW¼ NE¼ sec. 34, T. 11 S., R. 2 W., in a cut along Route 127, 22 feet of medium-grained, gray to light gray limestone is exposed. The beds dip about 10° roughly to the north. Sample NF 457 was taken from this exposure shortly after it was made.

Results of Tests

A chemical analysis of Sample NF 457 is given in table 3. It is a high-calcium limestone.

Uses

Parts of the Grand Tower Limestone, as exemplified by Sample NF 457, are of such purity that they probably could be used for some of the uses of high-calcium limestone previously discussed (p. 13). Sample NF 457 would be a good agricultural

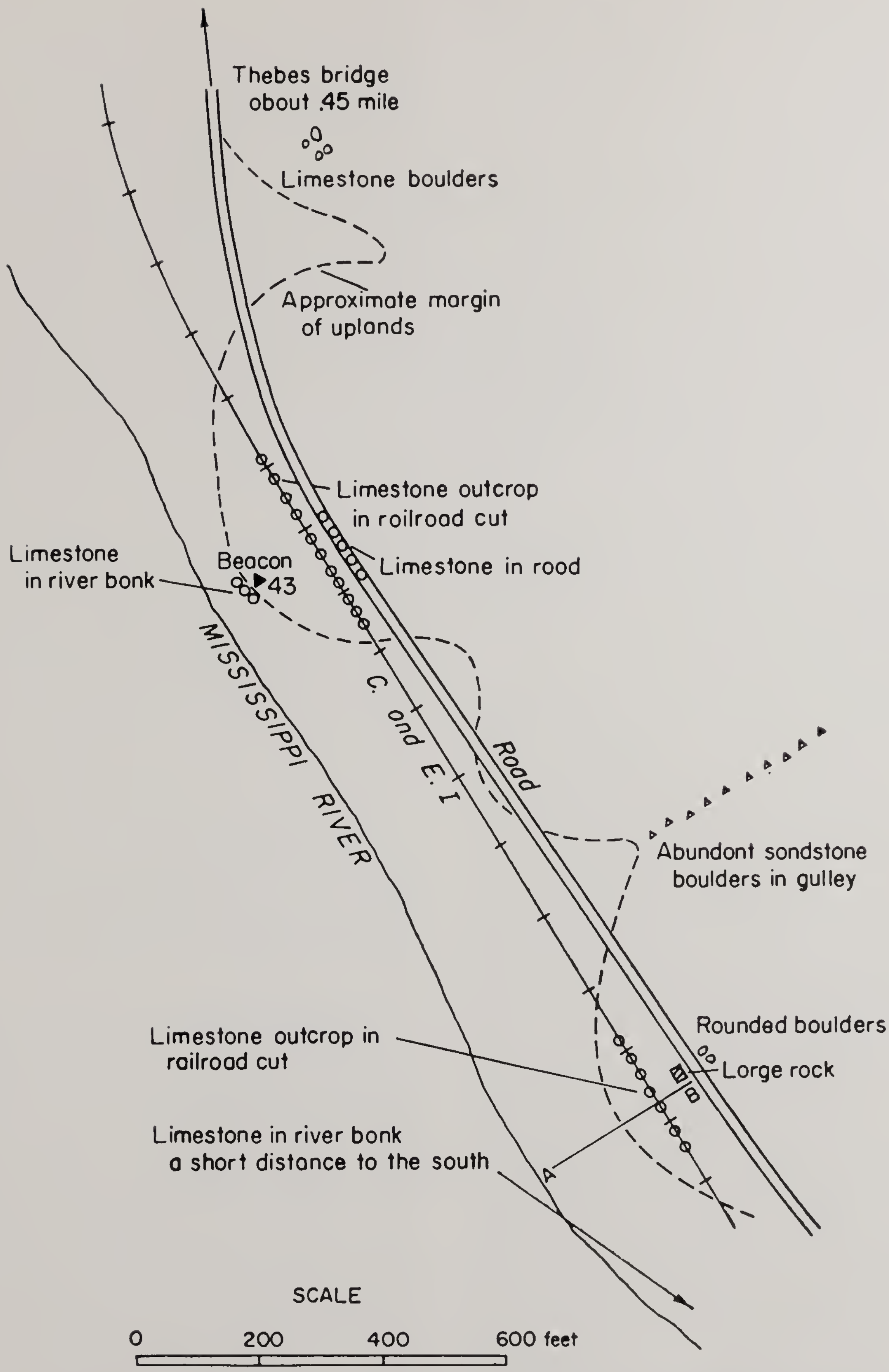


FIG. 3.—Sketch map of area south of Thebes. All limestone shown is Kimmswick Limestone.

limestone and its chemical composition is within the limits of limestone used in the raw mix for making portland cement.

Another sample, NF 519, from the same outcrop as Sample NF 457, was found to be suitable for portland cement concrete and higher types of bituminous road surfacings (table 6). It also would serve for railroad ballast and other physical uses (p. 14). The stone takes a good polish.

Kimmswick Limestone

Distribution and Character

The principal outcrop area of the Kimmswick Limestone in extreme southern Illinois occurs about one mile south of Thebes in the SE¼ sec. 17, T. 15 S., R. 3 W., Alexander County (pl. 1). The limestone also crops out at times of low water in Rock Island in the Mississippi River

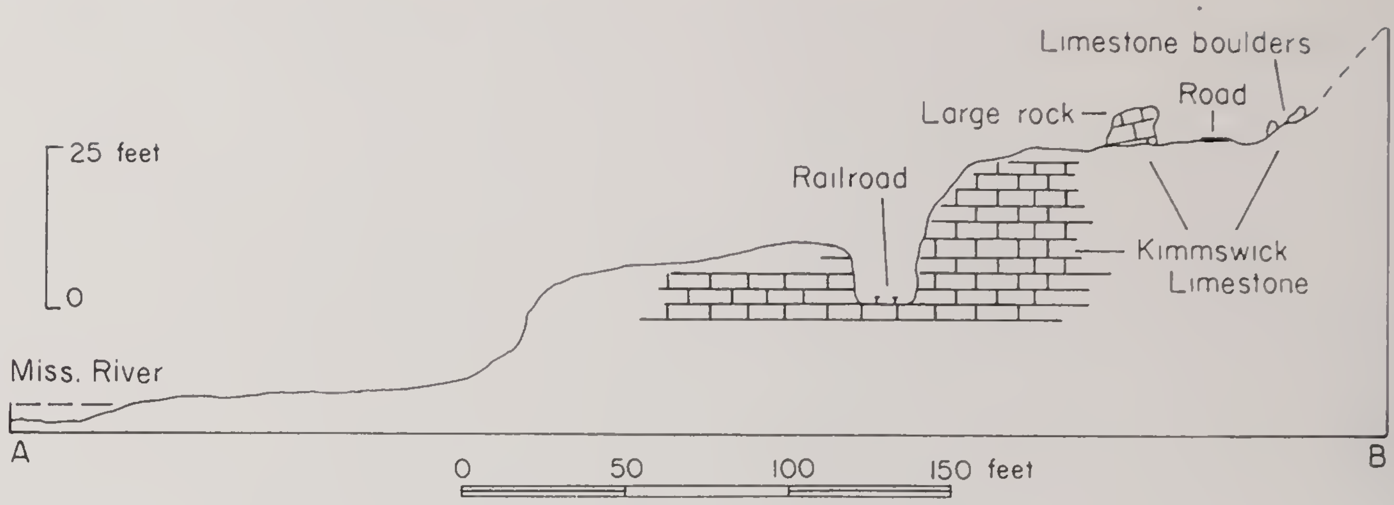


FIG. 4.—Rough cross section along line A-B of figure 3.

about half a mile southwest of Gale, and the piers of the railroad bridge at Thebes rest on the Kimmswick Limestone, which may be seen when the river is low.

The major features of the outcrop south of Thebes are shown in the sketch map, figure 3. The thickness of limestone now exposed is less than in earlier years because earth has washed over parts of some outcrops. Figure 4 is a rough cross section along the line A-B in figure 3. The probable area immediately underlain by the Kimmswick Limestone is indicated on plate 1.

Outcrops of the Kimmswick Limestone in the Thebes area are the result of erosion, by the Mississippi River, of an upfold in the bedrock. The axis or "long direction" of the fold is about NE-SW. The south side of the fold is probably somewhat steeper than the north side. As a result of the folding, the Kimmswick Formation lowers toward the northwest and southeast from the outcrops in sec. 17 and probably to the northeast also.

As shown in figure 3 the outcrops of the Kimmswick Limestone occur at or near the base of the bluff along the Mississippi River. The bluff rises to a height of about 150 feet above the river. There is, therefore, a considerable thickness of other earth materials resting on the Kimmswick Limestone in the river bluff. Probably part of the overlying material directly above the limestone is the Thebes Sandstone Member of the Maquoketa Formation. The exact thickness of the sandstone in the bluff is not known. The "Abundant sandstone boulders in gully" shown in figure 3 may have come from the Thebes Sandstone. Above the Thebes Sandstone, sands, clays, and gravel are present.

The combination of the relatively limited area of shallow limestone, the railroad, and the road, as shown in figure 3, pose a problem to open-pit quarrying of the limestone. Underground mining might be required in large-tonnage production of stone.

The Kimmswick Limestone is principally a medium to coarsely crystalline rock. It is generally light gray or white but is locally pink or light yellow. The limestone occurs in beds 1 to about 5 feet thick and much of it has a marble-like appearance. The upper part of the formation is finer grained than the lower part, is gray and contains scattered nodules of dark gray or black chert. Some of the upper limestone may be somewhat less pure than the underlying portion of the formation. All outcrops shown in figures 3 and 4 are of the lower medium or coarsely crystalline limestone, except some of the "limestone boulders" in the north part of the sketch that probably are from the upper limestone, and the "large rock" which also may be the upper limestone.

The thickness of the upper fine-grained limestone is not known exactly but may be about 30 to 35 feet. The total thickness of the Kimmswick Limestone probably is between 100 and 150 feet.

Results of Tests

A number of chemical analyses of samples from the Kimmswick Limestone are given in table 3 together with data regarding the sources of the samples. The samples are as follows:

NF 450—26 feet of limestone, northernmost of two outcrops along C and E I Railroad (fig. 3). Lower limestone. Sample from railroad cut and road.

L 63 A—Southernmost cut along C and E I Railroad and adjacent area to the east (fig. 3). Lower limestone.

L 58 —Same location as L 63 A, limestone in railroad cut. Lower limestone.

L 57 —Along river south of L 63 A. Lower limestone.

NF 522—13½ feet of limestone in southernmost cut along C and E I Railroad together with 15½ feet of Kimmswick exposed along the Mississippi River in the NW¼ NE¼ NE¼ sec. 20, T. 15 S., R. 3 W. Lower limestone.

Results of physical tests on Sample NF 522, in this instance representing 13½ feet of limestone in the southernmost railroad cut, figure 3, are given in table 6.

Uses

All samples of the Kimmswick Limestone tested are high-calcium limestone, suggesting that the limestone may be suitable for a number of the uses for this type of stone previously described (pages 14, 15). The low magnesium oxide content of the samples places them in the range of raw materials for making portland cement. Parts of the formation, where fresh, may be white enough to be used in making whiting.

The physical tests of the stone, table 6, indicate that it probably is too soft for cement concrete or bituminous concrete aggregate but it could probably be used for road stone. The upper part of the Kimmswick may be better for aggregate than the lower part, which was the part tested.

The lower limestone has a marble-like texture and takes a good polish and so has possibilities as a decorative marble and building stone. Polished specimens have an interesting textural pattern but may show small pores. The thick-bedded character of many of the strata is favorable to the production of the large blocks from which are sawed slabs and smaller blocks for polishing.

Kinkaid Formation

Distribution and Character

The Kinkaid Formation extends across southern Illinois and underlies an interrupted band from one-eighth of a mile up to almost two miles wide in places (pls. 2, 3, 5, and 6). In Hardin County the Kinkaid Formation is mapped with the underlying Degonia and Clore Formations as a unit. The Kinkaid is most likely to occur in the northern parts of the area shown to be underlain by the Kinkaid-Degonia-Clore unit, although in places it may have been removed by erosion.

The formation consists principally of limestone, although it also includes prominent shale units. The Kinkaid is the youngest limestone-bearing formation of consequence in extreme southern Illinois and is overlain by rocks of Pennsylvanian age that are principally sandstone with lesser amounts of shale. In most of the area under discussion the Kinkaid is the northernmost exposed limestone formation. The limestone units are of such thickness that they have been worked commercially at a number of places.

The thickness of the Kinkaid Formation varies. In western Union County the formation is generally less than 50 feet thick and is even absent in some places. In eastern Union County also, the formation is missing locally but in other parts of this area and in Johnson and Pope Counties it may reach a thickness of 140 feet. In many places it may be 100 feet or less thick. In eastern Pope County and in Hardin County the Kinkaid also varies in thickness but its maximum is about 200 feet. It is absent or thin in eastern Hardin County. The variation in thickness of the Kinkaid Formation results at least in part from its having been eroded to varying degrees by running water before the overlying Pennsylvanian sandstones and shales were deposited on it.

The limestones of the Kinkaid Formation are commonly fine- to medium-grained

and are gray to dark gray to almost black. They are well bedded in strata for the most part less than 3 feet thick. Much of the limestone is more or less siliceous and some of it contains pyrite in small crystals. Cherty limestone and beds of chert are present in some deposits. It is possible that the Kinkaid Formation contains greater continuous thicknesses of limestone in the western and central parts of extreme southern Illinois than in the eastern part. In Hardin County, shale is estimated to constitute about half of the formation, and limestone is most abundant in the upper part. Chert beds as much as a foot or more thick occur in the lower part.

The shale of the Kinkaid Formation is generally gray or dark gray, although in places red shale also is present. Thicknesses of 20 feet or more are known. Locally, as in Pope County, the formation includes a sandstone unit 5 to 15 feet thick. An idea of a shale and limestone relationship in the Kinkaid is given by the following section of rock exposed in the quarry at Cave Hill, near Somerset, in Saline County.

	Thickness ft.	*in.*
Covered		
Shale, gray, limy	10	
Shale, gray, with thin limestone beds, Sample NF 545 A	10	
Limestone, gray, fine- to coarse-grained	8	1
Shale, dark gray		2
Limestone, light to dark gray, some brownish, Sample NF 545 D	20	
Covered		

Another outcrop formerly exposed in the NE¼ NW¼ sec. 31, T. 11 S., R. 2 E., Johnson County, composing the upper 91 feet of the Kinkaid Formation, consisted of five limestone units that ranged from 1 foot 7 inches to 18 feet 4 inches thick and totaled 47 feet 11 inches; seven shale units that ranged from 1 foot 10 inches to 12 feet 4 inches thick and totaled 39 feet 10 inches in thickness; and one unit of interbedded limestone and shale 3½ feet thick.

At the Pine Hollow quarry in sec. 14, T. 13 S., R. 5 E., near Dixon Springs, six limestone units ranging from 1 foot to 17 feet 9 inches thick and totaling 36 feet thick have interbedded with them four shale units ranging from 1 inch to 4 inches thick and totaling 11 inches thick.

Results of Tests and Uses

Analyses of twelve samples of limestone from the Kinkaid Formation are given in table 3. The greatest thickness of limestone sampled was in the quarry near Buncombe in sec. 15, T. 12 S., R. 2 E., where 58½ feet was sampled, Samples 478 A, B, and C. Twenty-nine feet of limestone was sampled at the Pine Hollow quarry near Dixon Springs (Sample NF 550), and 20 feet in the Cave Hill quarry near Somerset, in Saline County (Sample NF 545 D). The other samples represent lesser thicknesses of stone.

The shale of the Kinkaid Formation is represented by Samples NF 478 D, NF 478 E, and NF 545 A, table 4.

Physical tests on three samples of limestone, NF 532, NF 556 C, and NF 550, are given in table 6 and still another sample, K 29, is reported in table 7.

The Kinkaid Limestone is used for agricultural limestone, road rock, and aggregate. Results of physical tests covering the character of the stone for the latter use indicate that the samples tested are suitable for portland cement and bituminous pavements. Some samples of the limestone passed 20 cycles of the sodium-sulfate soundness test, indicating the possibility that parts of the formation are suitable for use as filter stone in the trickling filters of sewage disposal plants.

Some beds of the limestone are almost black or mottled black and gray, have an attractive appearance, and take a good polish. Such strata may be sources of decorative marble, floor tile, and terrazzo chips.

Chemical analyses of the limestone, table 3, indicate that some of the stone is siliceous. Analyses of the shale are given in table 4, as are analyses of shale from the Pennsylvanian rocks that overlie the Kinkaid Formation. These, and the limestone analyses, suggest the possibility that combinations of shale and limestone whose composition will meet chemical specifications

for portland cement raw materials may be available in some places from the Kinkaid Formation or from the limestone of the Kinkaid and from Pennsylvanian rocks. However, some of the limestone is too high in magnesia to meet specifications.

The Southern Illinois Stone Company and Johnson County Stone, Inc., both at Buncombe, and the Columbia Quarry Company near Lick Creek are quarrying limestone of the Kinkaid Formation.

Levias Limestone Member

See discussion of Ste. Genevieve Formation, of which this limestone is a part.

Lingle Limestone and Alto Formation

A series of strata that crop out at only a few places and whose detailed character and variations are imperfectly known overlie the Grand Tower Limestone in Union and Alexander Counties. Early work (Savage, 1920a, 1920b) suggested that the beds included a shale unit at the base, overlain by the Lingle Limestone, above which was the Alto Formation. The latter formation consisted of shale and limestone, with the limestone in the upper part of the formation. More recent investigations (Weller and Ekblaw, 1940, p. 16) raise a question regarding the feasibility of attempting to recognize the three units in the outcrops.

The area underlain by the three units together is shown in plates 1 and 6. Known outcrops of the limestones are largely restricted to that part of the area from a point about 2½ miles south of Jonesboro to a point about three miles west of Cobden, but a few outcrops are reported two to three miles west of Mill Creek.

One of the best outcrops of the Lingle Limestone occurred in the south bank of Clear Creek in the NE¼ sec. 34, T. 11 S., R. 2 W. The exposure is now inferior to what it was earlier (Savage, 1920b) when it showed 43 feet of mostly impure, dark-colored limestone. Some of the limestone was cherty and a 7-inch bed of chert was present. Other less extensive outcrops were of the same general character. The maximum thickness of the Lingle Limestone may be 90 feet.

The limestone of the Alto Formation is believed to be of roughly the same nature as that of the Lingle Limestone. One of the better outcrops of the formation occurred along a creek in the SE¼ sec. 10, T. 12 S., R. 2 W., where 35 feet of impure limestone is reported. The thickness of the Alto is not known but is probably between 0 and 100 feet or more. Well records suggest that some of the limestone of the Alto Formation may be dolomitic.

No samples were taken of the limestones but because they are generally impure and contain chert their uses are likely to be limited, possibly to road rock. Conceivably some cement-making raw materials may occur in the formations.

Menard Formation

Distribution and Character

The area underlain by the Menard Formation extends as an interrupted band across extreme southern Illinois (pls. 2, 3, 5, and 6). The formation consists of limestone with varying thicknesses of interbedded shale. In northwestern Union County the formation reaches a thickness of about 90 feet. In eastern Union County its thickness ranges between 50 and 120 feet. The middle part of the formation is dominantly limestone with lesser amounts of interbedded shale, but in the upper and lower parts of the formation shale is the more common.

In Johnson and Pope Counties the Menard Formation is about 100 feet thick and is interbedded limestone and shale. The middle and lower parts of the formation are likely to be more shaly than the upper part. In Hardin County the thickness is about 120 feet and the formation is composed of limestone and shale, mostly the former.

The limestone of the Menard Formation is generally medium or dark gray and well bedded; many of the limestone beds are separated by thin partings of clay or shale. Chert is common in some strata. The composition of the limestone varies and includes some reasonably pure limestone as well as siliceous and clayey beds. The Menard Formation shales are generally gray or dark gray. Some are limy, others are not.

Results of Tests

Results of chemical analyses of the limestone and data regarding deposits sampled are given in table 3. Analyses of the shales appear in table 4. Results of physical tests are given in table 7.

Sample NF 531 was taken from 21 feet 7 inches of the Menard Limestone exposed in a gully north of Saratoga. The four ledges of limestone sampled were separated by intervals of a total thickness of 5 feet where no rock was exposed. These covered intervals may be shale.

Another outcrop along Route 37 about half a mile north of West Vienna exposed 26 feet of bedrock of which 16 feet 11 inches was limestone (Sample NF 558A) and 9 feet 1 inch was calcareous shale interbedded with shaly limestone or containing limestone nodules (Sample NF 558C).

Samples T 1 to T 5 were taken from the south portal of the Flatwoods Tunnel a few miles northeast of Grantsburg shortly after the tunnel was made. The exposed strata were as follows:

	Thickness feet
Top of exposed bedrock.	
Limestone and shale interbedded. About 85 percent of this unit is limestone. Sample T 5 is the limestone from this unit and T 4 the shale.	40
Shale and limestone interbedded in about equal amounts. Much of the limestone is siliceous. There are beds of chert in the upper part of the unit. Sample T 3 represents the entire unit.	33
Shale, dark gray. Sample T 2.	4
Limestone, dark gray, in beds about 12 inches thick. Sample T 1.	7
Bottom of exposure.	

An average of the above analyses, weighed according to the thickness of the strata represented by each, and thus representing the entire 84 feet of rock exposed, is:

CaO	35.89%
MgO	3.08
$CaCO_3$ (calculated)	64.09
$MgCO_3$ (calculated)	6.44
SiO_2	19.09
Fe_2O_3	2.71
Al_2O_3	5.31

Uses

The analyses of the Menard Limestone suggest that in general it is not high-calcium limestone. A comparatively high silica content characterizes several of the samples. Some of the limestone could be used for agricultural limestone and road rock. Certain strata are likely to be suitable for aggregate for concrete and for bituminous roads.

Probably some combinations of limestone and shale could be worked out whose chemical composition would be within the range of raw materials for portland cement; however, the magnesium oxide content may be a problem in some deposits.

The shale interbedded with the limestone deposits of the Menard Formation plus the probable variation in thickness and character of the limestone and shale should be considered in relation to large-scale quarrying and the production of a quarry product of chemically and physically uniform character.

Moccasin Springs Formation

(See also Bainbridge Group)

The Moccasin Springs Formation is a part of the Bainbridge Group of rocks whose distribution has been mentioned. It consists of earthy limestone at its base and grades upward into calcareous red, green, or gray shale. This shale in turn grades upward into the shale that is the lower part of the overlying Bailey Formation.

In the Mississippi River bluffs east of McClure in the SW¼ SE¼ NW¼ sec. 12, T. 14 S., R. 3 W., 6 feet of interbedded relatively pure and impure limestone resting on 23½ feet of purer limestone of the St. Clair Formation probably marks the change from the St. Clair to the Moccasin Springs Formation. Earthy limestone of the Moccasin Springs crops out, among other places, along the road in the SW¼ SE¼ SW¼ sec. 21, in the bed of Orchard Creek in the SE¼ SE¼ SW¼ sec. 22, along a creek in the SE¼ SW¼ sec. 2, and in a small valley in the SW¼ NE¼ SE¼ sec. 28, all in T. 15 S., R. 3 W.

A good outcrop of the upper shaly portion of the Moccasin Springs or the lower

shale of the Bailey Formation occurs in the south bank of Horse Creek in the SW¼ NW¼ SW¼ sec. 23, T. 14 S., R. 3 W., where 25 feet of gray-green shale containing scattered limestone nodules is visible. The shale grades upward to the chert of the Bailey Formation.

The exact thickness of the Moccasin Springs Formation is not known. The record of a well near Unity in sec. 35, T. 15 S., R. 2 W., notes 5 feet of limestone overlain by 90 feet of shale that may be the Moccasin Springs. The record of another well drilled in sec. 6, T. 14 S., R. 2 W., reports 145 feet of shaly limestone that may be Moccasin Springs.

Results of Tests

Sample NF 524 represents 15 feet of impure limestone of the Moccasin Springs Formation along Orchard Creek. A chemical analysis and location details are given in table 3. Similar data for Sample NF 528 and Sample L 62 from shale of the Moccasin Springs Formation or the lower part of the Bailey Formation are given in table 4.

Uses

The magnesium oxide content of Sample NF 524 is within the limits for limestone used for making cement. The sample has a carbonate content of 72 percent, which limits its possible uses. It might be usable for making rock wool if somewhat more impure deposits than that sampled can be found. The silica ratio of Sample NF 528 is above the rough maximum for making cement.

Paint Creek Formation

The Paint Creek Formation is largely shale but it is mentioned briefly because it contains limestone layers in some places. The formation cannot be distinguished from the Renault Formation in much of Union County because the Bethel Sandstone, which usually separates the two formations, is absent. In northeastern Union County the formation may be about 25 feet thick. It consists of limestone and shale. In Johnson and Pope Counties the Paint Creek Formation commonly consists largely of shale with a few beds of limestone that generally are impure. The thickness of the formation ranges roughly from 40 to 60 feet. In Hardin County the formation is as much as 60 feet thick and is largely sandstone and shale.

The Paint Creek Formation does not appear to offer general possibilities for the production of limestone although it may serve as a local source in some areas. Sample L 20 from Union County is a moderately pure limestone and would serve as agricultural limestone, road stone, and possibly for other uses.

Renault Formation

Distribution and Character

The Renault Formation underlies a narrow band extending from northwestern Union County eastward to northern Massac County (pls. 2, 3, 4-A, 5, and 6). The formation consists of interbedded limestone and shale strata. The limestone is commonly gray or dark gray; some strata are oolitic. The shale beds are gray, green, or, less commonly, red.

In Union County the formation is less than 45 feet thick. Its exact thickness is not known because in much of the county the Bethel Sandstone, which usually separates the Renault and Paint Creek Formations, is absent and the two formations are in contact.

The formation is about 60 feet thick in Johnson County. Near Belknap a 51½-foot exposure in an abandoned quarry consisted of 23½ feet of limestone interbedded with 28 feet of shale. The thickness of the individual shale units ranged from 5 inches to 15 feet and of the limestone beds from 1½ to 10 feet. Samples NF 551 L and NF 551 S were taken from this deposit.

In Pope County the formation is mainly limestone ledges separated by variable amounts of shale. The limestone in the upper part of the formation is cherty.

About two miles west of Indian Point in northern Massac County a 34-foot outcrop of the Renault consisted of 21 feet of limestone in strata up to 9 feet thick interbedded with 13 feet of shale in beds up to 5 feet thick (Samples NF 552 L and NF 552 S).

In Hardin County the formation is about 90 feet thick. Approximately the upper third is gray limestone, some parts of which are oolitic. Chert is present in some places. The lower two-thirds of the formation consists of about equal amounts of limestone and shale in layers, most of which range up to 3 or 4 feet thick, but thicker strata are present. Beds of sandy and shaly limestone occur at some places. In an abandoned quarry near Shetlerville in Hardin County an exposure of the Renault Formation visible some years ago was 74 feet thick and consisted of alternating layers of limestone and shale beds, each as much as 11 feet thick. Of the total outcrop 45 feet was limestone and 29 feet was shale (Samples NF 555 A, NF 176 C, and NF 176 D).

Results of Tests and Uses

The chemical character of the limestone in the Renault Formation is indicated by analyses in table 3. Analyses of shale from the formation are given in table 4. The results of physical tests on the limestone are given in table 6. In table 7, Sample 7617, which is probably Renault, gives other physical test data.

None of the samples analyzed chemically was high-calcium limestone but the Renault Formation does contain some strata of good purity. The magnesium oxide content of the beds sampled is low enough to meet specifications for limestone to be used in the raw mix for making portland cement. The limestone also could be used for agstone and road rock. Physical tests indicate that some of the limestone (Sample NF 552) meets specifications for concrete aggregate and aggregate for bituminous roads, and that some of it (Sample NF 560) is of borderline character. The magnesium oxide content of the samples of Renault Shale is within the limits of shale for use in cement making.

The major problem in connection with commercial use of the limestone is the shale that is interbedded with it. Both the shale and limestone beds probably vary in thickness from place to place so that the amount of each present in different outcrops likewise varies. Separate quarrying of the shale and limestone strata would be expensive. The natural deposits of limestone and shale, if they were quarried as a unit, might provide a relatively low-testing agricultural limestone. The purer limestone would have to be separated from the shale and shaly limestone, however, to provide aggregate for concrete and bituminous roads, and probably for road rock.

St. Clair Formation

(See also Bainbridge Group)

The St. Clair Formation, which is part of the Bainbridge Group of rocks, consists of limestone of relatively high purity. It is well exposed in the Mississippi River bluffs east of McClure in the SW¼ SE¼ NW¼ sec. 12, T. 14 S., R. 3 W., where it is 23½ feet thick. It is dark red with greenish mottlings and occurs mostly in heavy beds up to 7 feet thick. Another outcrop of the St. Clair Limestone is reported along the south side of the valley in the SE¼ SE¼ sec. 20, T. 13 S., R. 2 W. Along the road south of Thebes in the SW¼ SE¼ SW¼ sec. 21, T. 15 S., R. 3 W., 5 feet of limestone of the St. Clair type overlain by 6 feet of earthy limestone, probably Moccasin Springs Formation, is visible.

The exact thickness of the St. Clair Limestone is not known. Besides the 23½-foot thickness mentioned above, the record of a well near Unity in sec. 35, T. 15 S., R. 2 W., reports 40 feet of limestone that may be the St. Clair. However, in the record of another well in sec. 6, T. 14 S., R. 2 W., no St. Clair Limestone can be definitely identified.

Results of Tests

Sample NF 449 was taken from 23½ feet of the St. Clair Limestone exposed in the Mississippi River bluffs east of McClure. Results of a chemical analysis of this sample are given in table 3. Results of physical tests on another sample, NF 526, from the same exposure are given in table 6.

Uses

Sample NF 449 from the St. Clair Limestone is a high-calcium limestone and prob-

ably would be suitable for some of the uses for this type of limestone, described on page 14. It would be a satisfactory agricultural limestone. The physical tests of a sample, NF 526, from the same deposit indicate its suitability for cement concrete, bituminous concrete, railroad ballast, road rock, and similar uses. Because of its uncommon color, red with green mottlings, the limestone is of interest as a possible source of building stone and for use as marble for decorative purposes. It takes a satisfactory polish, and the heavy beds that characterize it in places favor the production of the large blocks required for decorative marble. Polished specimens have been said to resemble an imported marble having the trade name of Levanto.

Sample NF 449 meets the magnesium oxide (MgO) requirements for limestone used for making portland cement.

St. Louis Limestone

Distribution and Character

The St. Louis Limestone crops out principally in Union and Hardin Counties (pls. 2, 4-B, and 6). In Union County it underlies an area beginning at a point about two miles northwest of Mountain Glen and extending and widening southeastward into the northern part of Pulaski County. The formation consists mainly of fine- and medium-grained, gray or dark gray, well bedded limestone with more coarsely crystalline layers in some parts of the formation. Chert is present in varying amounts in many parts of the formation. The St. Louis is probably 200 to 300 feet thick but outcrops are generally of limited vertical extent.

The formation also underlies considerable areas in northwestern and central Hardin County. The bluffs of the Ohio River are composed of this limestone and it underlies an area adjacent thereto in the vicinity of Cave in Rock and westward to within about two miles of Elizabethtown. Some of the best outcrops of the limestone occur in this area. The limestone in general is fine-grained. The upper part of the formation is gray but the color darkens downward so that the lower part of the formation is almost black. Chert is relatively common in many beds of the limestone. The thickness of the formation in Hardin County may exceed 500 feet. The St. Louis grades into the formations below and above.

Results of Tests

Chemical analyses of samples of the St. Louis Limestone are given in table 3. Physical tests of two samples are given in table 6.

Uses

The chemical analyses suggest that in general the St. Louis is not high-calcium limestone; some strata are dolomitic limestone. Some of the samples are relatively high in silica but the calcium carbonate plus magnesium carbonate content of others is 95 percent. The parts of the formation low in chert or free from it probably could be used for agricultural limestone, especially those portions containing more than 90 percent calcium carbonate plus magnesium carbonate. The physical tests on two samples indicate that parts of the formation are a satisfactory aggregate for portland cement concrete and higher types of bituminous road surfacing and are likely to be acceptable as railroad ballast. The formation also can supply riprap and rubble. The samples tested did not contain chert. The presence of appreciable amounts of chert in parts of the limestone probably would restrict the use of such stone.

With one exception the samples tested contained more than 3.2 percent magnesium carbonate and hence would be of doubtful value for portland cement manufacture. Parts of the formation other than those tested may contain less magnesium carbonate and, if relatively chert free, may be acceptable for use in cement making. Some of the black limestone strata of the St. Louis Formation are hard and if suitably crushed might have use as terrazzo chips. They also may afford a source of black or almost black marble.

Ste. Genevieve Formation

The Ste. Genevieve Formation consists of four subunits or members, in ascending

order the Fredonia Limestone Member, the Rosiclare Sandstone Member, the Levias Limestone Member, and the Hoffner Member, which is principally sandstone. The Fredonia Limestone is the thickest and most extensive of the four members and ordinarily is likely to be of greatest economic importance. The Hoffner Member has been described only as it occurs in Union and Johnson Counties.

There are two principal areas where the Ste. Genevieve strata occur, one in the western part of southern Illinois in Union and adjacent parts of Johnson and Pulaski Counties (pls. 3, 4-B, and 6) and the other in the eastern part of southern Illinois in Hardin and Pope Counties (pls. 2, 5). A few outcrops are known in Massac County (pl. 4-A).

UNION AND JOHNSON COUNTIES

Distribution and Character

In Union and the adjacent counties the various members of the Ste. Genevieve Formation have been mapped together as a single unit. The Fredonia Limestone probably is between 150 and 300 feet thick, being thickest in the eastern part of the area, and is well exposed in the quarries of Charles Stone Company at Whitehill and Anna Quarries, Inc., at Anna. The Rosiclare Sandstone is about 10 to 12 feet thick in the eastern part of the area but has not been positively identified in the western part. The Levias Limestone probably reaches a thickness of 40 feet in the eastern part of the area but it too has not been definitely distinguished to the west. The Hoffner Member averages about 30 feet thick in the western portion of the area but increases to 50 to 80 feet in the eastern part.

Because the members of the Ste. Genevieve Formation are not mapped separately, it is not possible to trace their individual positions. However, the Fredonia Member is likely to underlie roughly the half or two-thirds of the mapped area adjoining the area mapped as the St. Louis Limestone.

The Fredonia Limestone generally consists of an alternation of relatively thick units of light- and dark-colored limestone, most of which is oolitic. Beds of almost white oolite, low in impurities, are especially common in the upper part of the formation. The dark strata are likely to be somewhat less pure than the light beds. Chert in small amounts is scattered through some of the upper Fredonia strata but is more common in the lower dark beds. The Levias Limestone is similar to the Fredonia but is commonly less cherty.

Results of Tests

Results of tests on a number of samples of limestone from the Ste. Genevieve Formation (Fredonia Member) in Johnson and Union Counties are given in table 3. It will be noted that some of the units sampled are high-calcium limestone, such as Samples NF 174 A and NF 175 D. Other units are dolomitic and contain considerable magnesium carbonate (Samples NF 175 A and NF 175 C).

Uses

Ste. Genevieve stone has been or is used commercially for a wide variety of crushed stone purposes, including concrete aggregate, bituminous road surfacings, blacktop chips, railroad ballast, and agricultural limestone. The high-calcium units may be suitable for some of the uses of high-calcium limestone previously mentioned. Parts of the formation appear to be of composition suitable for use as a part of the raw mix for portland cement manufacture. Many of the oolite beds of the Ste. Genevieve Formation take a good polish and may be useful as decorative marble as well as for exterior construction. From suitable beds the formation also will supply riprap, rubble, and probably filter stone for sewage disposal plants.

HARDIN AND POPE COUNTIES

Distribution and Character

The Fredonia Limestone, Rosiclare Sandstone, and Levias Limestone are mapped together on the Hardin and Pope Counties map (pls. 2 and 5) to reduce the complexity of the maps and because the Rosiclare Sandstone and Levias Limestone generally are thin and do not underlie ex-

tensive areas, except for a tract in the vicinity of and south of Eichorn where the area underlain by the Rosiclare Sandstone is more extensive.

Because of lack of detailed information, the Pope County map (pl. 5) does not extend south of Bay City. However, an outcrop of limestone believed to be Ste. Genevieve was noted at the north edge of Hamletsburg in a small valley in the NW¼ NW¼ sec. 10, T. 16 S., R. 7 E., where about 10 feet of fine-grained limestone is exposed. Another outcrop is reported (Worthen, 1866) to occur at low water in the bed of the Ohio River in the SW¼ sec. 34, T. 15 S., R. 7 E. The extent of the deposit represented by these outcrops is unknown but may be limited.

The Fredonia Limestone is gray to dark gray, occurring in comparatively heavy beds. Strata of nearly white oolite are present and are more common in the upper part than in the lower part. Chert is common in the lower part of the Fredonia Limestone; in the higher part it occurs in lesser amounts at some places. Locally a sandy zone reaching a maximum thickness of about 10 feet occurs 50 to 60 feet below the top of the Fredonia Limestone. The limestone grades into the underlying St. Louis Limestone and consequently its exact thickness cannot be determined. It is believed to be between 180 and 250 feet.

The Levias Limestone is similar to the Fredonia Limestone, being partly oolitic, and light gray to white, with some darker colored strata. Some of the stone has a purplish or reddish cast. Its thickness ranges from about 0 to 35 feet or more.

Results of Tests

Table 3 gives the results of chemical analyses of a number of Ste. Genevieve samples in Hardin and Pope Counties. Results of physical tests are given in tables 6 and 7.

Uses

The purity of the samples analyzed varies but some samples are high-calcium limestone, probably suitable for some of the uses for this type of limestone previously mentioned, page 14. The purer beds are commonly oolitic. Other samples are more or less dolomitic and some are impure.

The non-cherty beds of the Ste. Genevieve are used for a variety of purposes including aggregate, agricultural limestone, and road stone. The two samples tested also were suitable for concrete and the higher types of bituminous road surfacings. The chemical analyses indicate that the composition of the Ste. Genevieve Formation probably is such that parts of the formation are likely to be suitable components of the raw mix from which portland cement is made. Riprap, rubble, and building stone also could be obtained from parts of the formation, especially the purer non-cherty strata. Some of the non-cherty strata, especially the oolites, take a good polish and may have possibilities as decorative marble and also for exterior construction purposes.

PULASKI AND MASSAC COUNTIES

Several low hills and ridges in secs. 2 and 3, T. 14 S., R. 1 E., north of Perks in Pulaski County are believed to be underlain by Ste. Genevieve deposits. The limestone also is exposed along the shore of the Ohio River at low water for about 500 feet east of Douglas Landing in the SE corner sec. 2, T. 15 S., R. 2 E., Pulaski County. The stone is fine-grained, dark gray and locally oolitic. Other outcrops, believed to be Ste. Genevieve, are visible along the Ohio River in the SE¼ sec. 2 and in the bed of Post Creek cutoff where it intersects the road in the NE¼ SW¼ sec. 2, T. 15 S., R. 2 E. Test drilling of the latter outcrop revealed that it is the top of a pinnacle of limestone having no great lateral extent.

In Massac County, limestone of the Ste. Genevieve Formation is quarried for a variety of uses about a mile north of Mermet in the E½ sec. 22, T. 14 S., R. 3 E. A small hill in the center of sec. 15 of the same township at one time exposed 25 feet of compact, blue-gray limestone of the Ste. Genevieve Formation, and a small outcrop of cherty limestone, also Ste. Genevieve, is reported in a ridge near the center of sec. 8, in the same township (Krey and Lamar, 1925).

OPERATING QUARRIES

The following quarries are producing limestone for various commercial uses from the Ste. Genevieve Formation:

Anna Quarries, Inc., Anna
Charles Stone Company, Whitehill
Columbia Quarry Company, Shetlerville
Columbia Quarry Company, Mermet
Denny and Simpson Stone Company, Elizabethtown
Okerson Quarry Company, Cave in Rock
Rigsby and Barnard Quarry, Cave in Rock

Salem Limestone

See Warsaw-Salem Limestone.

Sexton Creek Limestone

The Sexton Creek Limestone crops out in southwestern Union and northwestern Alexander Counties, and its distribution is shown on plates 1 and 6 where it and overlying Bainbridge strata are mapped together. The Sexton Creek Formation is a cherty limestone, the chert occurring as nodules or beds as much as 8 inches thick. The limestone is light gray, gray, or dark gray, finely to medium crystalline, and occurs in beds up to 2 feet thick. The formation varies in thickness; the maximum thickness observed was 49 feet. Overburden on most deposits consists of other bedrock formations and/or clayey silt.

A good exposure of the Sexton Creek Limestone may be seen in the Mississippi River bluff at the center of the W½ sec. 12, T. 14 S., R. 3 W., east of McClure, where about 25 feet of cherty limestone composes a steep face at the base of the bluff and is overlain by Bainbridge strata. Another good outcrop occurs in the SE¼ SW¼ SW¼ sec. 27, T. 14 S., R. 3 W., where 49 feet of the Sexton Creek Limestone is exposed. Sample NF 525 L was taken from the 36 feet of stone accessible for sampling at this place. The sample is from the limestone only and does not include the interbedded chert. Analysis of the 9 feet of chert in the outcrop follows:

SiO_2	79.40%	Na_2O	0.05%
Al_2O_3	1.69	K_2O	0.15
Fe_2O_3	0.24	CO_2	7.91
MgO	0.11	Ignition loss	8.45
CaO	9.94		
$CaCO_3$ (calculated)			17.74
$MgCO_3$ (calculated)			0.23

The analysis of Sample NF 525 L (table 1) shows that the limestone portion of the formation is relatively high in calcium carbonate but the abundance of chert restricts its possible usefulness.

Vienna Formation

The Vienna Formation underlies a narrow area extending across southern Illinois, with some interruptions, from western Union County to Hardin County (pls. 2, 3, 5, and 6). The formation is mostly limestone though shale is present in varying amounts; in parts of Union County the formation is largely shale. Ordinarily the Vienna Formation is overlain by a sandstone that separates it from the Menard Formation which lies above the sandstone. In some places, however, as in north-central Union County and parts of Hardin County, the sandstone is absent or inconspicuous and the Vienna and Menard Formations cannot be readily distinguished.

The Vienna Formation generally is about 20 to 30 feet thick, but in parts of Johnson and Pope Counties it reaches thicknesses of 60 to 70 feet.

The limestone of the Vienna Formation generally is medium to dark gray and fine- to medium-grained. Many of the limestone strata are impure; some contain interbedded chert. Chert also occurs as layers interbedded with the limestone, as in the SW¼ NE¼ sec. 12, T. 13 S., R. 4 E., in an exposure along the Illinois Central Railroad north of Grantsburg and about one mile north of Route 146 where the following bedrock strata are exposed:

	Thickness ft.	*Thickness* in.
Shale, brown, and black (Sample NF 520)	25	
Covered	6	
Shale (Sample NF 520)	12	
Limestone, fine- to coarse-grained, dark gray	1	4
Limestone of various textures and purities, including 4 beds of chert totaling 17" thick (Sample NF 521; does not include chert)	20	4
Shale, gray, with a 6- to 8-inch coal bed	6+	
Covered		

Results of Tests

Results of chemical analyses of limestone of the Vienna Formation are given in table 3 and of shale in table 4. Results of physical tests on Sample NF 521 are given in table 6, and table 7 gives other physical tests on a sample of limestone believed to be from the Vienna Formation.

Uses

The samples of limestone tested are not of high chemical purity but probably are suitable for agricultural limestone and road rock. Some of the non-cherty, shale-free limestone is satisfactory for portland cement concrete and bituminous roads, but whether sizable uniform deposits of such limestone are available is not known.

The MgO content of the limestone samples tested is above the limit for materials for making portland cement. A sample of shale from the Vienna Formation is within the MgO and rough silica ratio limits. There is a possibility that limestone samples from other places might be lower in their MgO content.

Warsaw-Salem Limestone

The Warsaw-Salem Limestone crops out in two areas of southern Illinois, in Alexander, Pulaski, and Union Counties, and in Hardin County. Because the areas are widely separated, they are discussed individually.

ALEXANDER, PULASKI, AND UNION COUNTIES

A thick series of limestone beds overlying the chert and siliceous limestone of the Keokuk-Burlington Formation and underlying the St. Louis Limestone occurs in Alexander, Pulaski and Union Counties. The name Warsaw-Salem Limestone has been applied to these strata. In some parts of Illinois it is possible to separate the Warsaw and Salem Formations, but in southern Illinois they have not been separated because no clear cut line of demarcation has been recognized. Krey (1922) mentions the presence in the area of strata containing "fossils common to the Warsaw," thus suggesting that the formation is present. The highly clastic character of the limestone below the St. Louis Limestone suggests the Salem Limestone. *Endothyra baileyi,* a fossil commonly found in the Salem in western Illinois and elsewhere, was not seen in these three counties.

Character of Limestone

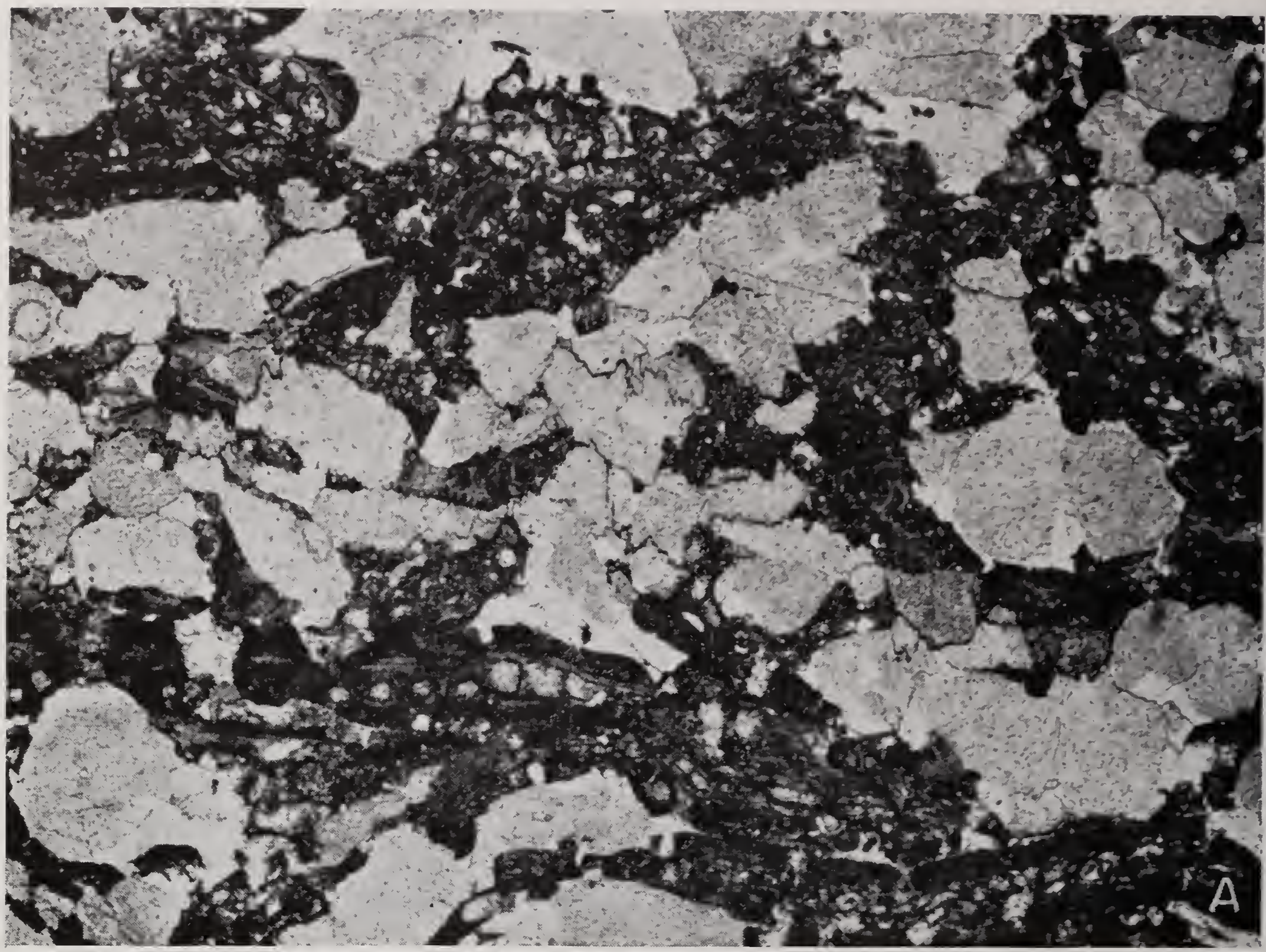
Most of the limestone of the Warsaw-Salem Formation consists of comparatively coarse particles of gray or brownish calcite in a fine-grained gray to white matrix. The texture is characteristic of the limestone regardless of whether the stone is coarse-, medium- or fine-grained (pls. 7, 8A). In some strata the matrix is dominant; in others the coarse particles are the more abundant.

The coarse particles range downward from about 3/16 of an inch in diameter in size. They include pieces of crinoid stems or other parts of crinoids as well as particles of calcite that probably are parts of some other organism, possibly some of the less delicate parts of fenestellid bryozoa. As seen under high magnification, the coarse particles commonly have a speckled or cloudy appearance, probably due either to included minute bits of organic matter, to minute fluid inclusions, or to both (pl. 7A). The margins of some of the coarser particles are comparatively clear calcite resulting from recrystallization of the particles or the addition of calcite to them.

The matrix of the limestone consists principally of many small fragments of the lacy fronds of bryozoa of the general fenestellid type (pls. 7, 8A). Some of the particles are elongate, others are irregular in shape, and still others resemble small "eyes" or multiples thereof.

The over-all color of much of the limestone is light gray, but some of it is medium or dark gray. Less commonly the limestone is buff. Plate 8B includes both medium and dark gray stone. The various shades of grayness in the limestone are believed to be due largely to variations in the amount of organic material present, the greater amounts producing the darker colors.

Some of the limestone, most commonly the finer grained samples, contains scattered crystals of the mineral dolomite (pl. 8B).


A


B

The maximum amount of dolomite noted was about 15 percent. It is likely that oxidation of the ferrous iron in the dolomite in some of the fine- or medium-grained beds is responsible for the buff color they have locally. The lighter buff color of the coarse-grained limestone in some places where it is overlain by surficial materials is probably due to the infiltration, by means of groundwater, of small amounts of iron oxide from overlying materials.

Chert is present in some places in parts of the Warsaw-Salem Limestone and generally occurs in the medium- and fine-grained stone, most frequently in the middle and lower parts of the formation. It commonly occurs in scattered nodules or, less commonly, in thin layers.

The Warsaw-Salem Limestone, especially the coarse-textured stone, is composed mainly of thick strata. Some beds show cross bedding. Stylolites are common, and the vertical amplitude of their various cusps ranges from microscopic to an observed maximum of 5 inches.

Thickness

The maximum thickness of the Warsaw-Salem Limestone is estimated to be about 600 feet.

Major Textural Types

The exposures of the Warsaw-Salem Limestone leave much to be desired from the standpoint of determining the details of the stratigraphy of the formation as a whole. It appears that the upper part of the formation is characterized by light-colored, coarse-grained limestone, whereas the lower part is more likely to be medium- to fine-grained and includes more medium gray and dark gray limestone. However, medium- and fine-grained limestone of medium or dark gray color may occur at some places in the upper part of the formation, and coarse-grained beds may be present in the lower part.

The coarse, generally light gray upper portion of the Warsaw-Salem Limestone is best exposed in an area north of Mill Creek, an area where some of the stone is softer and has a more chalky appearance than in other areas. For convenience the coarse-grained type of limestone is herein referred to as the Mill Creek type, even though it is not necessarily all as soft as that at Mill Creek. The medium- or fine-grained, medium or dark gray locally cherty limestone is referred to as the Kornthal type, the name being taken from Kornthal church a few miles south of Jonesboro, in the vicinity of which this type of limestone is exposed at several places.

Outcrops of the Kornthal type of limestone occur most commonly in the western part of the area mapped as Warsaw-Salem in plates 1, 4B, and 6. A good exposure of the limestone has been visible in an abandoned quarry just south of Kornthal church in the SW¼ NE¼ SE¼ sec. 1, T. 13 S., R. 2 W. About 20 feet of the limestone is exposed in the cut along the east-west road a little east of the center of the west line of sec. 18, T. 13 S., R. 1 W., and it is visible in a cut along the Gulf, Mobile and Ohio Railroad in the northwest corner of the

EXPLANATION OF PLATE 7

A.—Photograph by transmitted light of a thin section of the coarse-grained variety of Warsaw-Salem Limestone. The section is perpendicular to the bedding of the rock, which extends from left to right. Magnified 20 times. The large light-colored areas are pieces of fossils. probably crinoid stem or calyx fragments and pieces of the less fragile parts of fenestellid bryozoa. The darker material with the lacy pattern is composed of the frond-like. more fragile parts of fenestellid bryozoa. The light gray and white areas in the thin section are the gray or dark gray, coarse particles seen in pieces of the limestone viewed with the naked eye. The dark areas in the thin section are the fine-grained, light gray or white matrix of the limestone. These differences in color are a function of the ease with which the materials in the thin section transmit light.

B.—The limestone photographed is similar to A but is the medium-grained variety of Warsaw-Salem Limestone. Magnified 20 times.

same section. It also can be seen in the quarry of Columbia Quarry Company at Ullin.

Outcrops of the Mill Creek type of limestone occur most commonly in a zone about one-half to three-quarters of a mile wide which borders on the west the line marking the base of the St. Louis Limestone (pl. 6), indicating that the Mill Creek type of limestone lies immediately below the St. Louis Limestone. This relationship is well shown in the NE¼ SW¼ sec. 17, T. 13 S., R. 1 W.

A good exposure of about 60 feet of the Mill Creek type of limestone has been visible in the quarry of the Jonesboro Stone Company in the S½ SW¼ sec. 17, T. 13 S., R. 1 W.

The Pure Limestone Company sank a diamond drill hole on top of a hill in the SW corner SE¼ sec. 20, T. 13 S., R. 1 W., northeast of Mill Creek, and examination of the core revealed that the Mill Creek type of limestone extended from 78 to 407 feet deep. When the core was examined that part shallower than 78 feet was missing and the Mill Creek type of limestone may have been thicker than indicated. One small piece of chert was noted at 373 feet. There was a gap in the core from 407 to 420 feet. However, from 420 to 446 feet the stone encountered was of the Kornthal type. A little chert was cut at 430 feet.

The Columbia Quarry Company quarry in the S½ NE¼ sec. 14, T. 14 S., R. 1 W., near Ullin affords a good exposure of the Warsaw-Salem Limestone, including both Mill Creek and Kornthal types. The former type has a light gray or gray color and appears to be harder than the Mill Creek type of stone north of Mill Creek. In a rough way the amount of stone of the Mill Creek type decreases downward from the top of the quarry whereas the amount of Kornthal-type stone increases.

In addition to the foregoing, other outcrops containing or made up of the Mill Creek type of limestone were noted at the following places south of Jonesboro:

Agatan Stone and Machinery Company quarry
NE¼ SE¼ sec. 29, T. 13 S., R. 1 W.

Lutz Marble Company quarry
SW¼ sec. 17, T. 13 S., R 1 W.

Abandoned quarry
SW¼ NE¼ SE¼ sec. 29, T. 13 S., R. 1 W.

Abandoned quarry
W½ NE¼ SE¼ sec. 20, T. 13 S., R. 1 W.

Outcrop
N½ SW¼ sec. 28, T. 13 S., R. 1 W.

Outcrop
Center S½ S½ sec. 33, T. 13 S., R. 1 W.

Outcrop
NW¼ NW¼ NE¼ sec. 3, T. 14 S., R. 1 W.

Outcrop
NW¼ NE¼ SE¼ sec. 10, T. 14 S., R. 1 W.

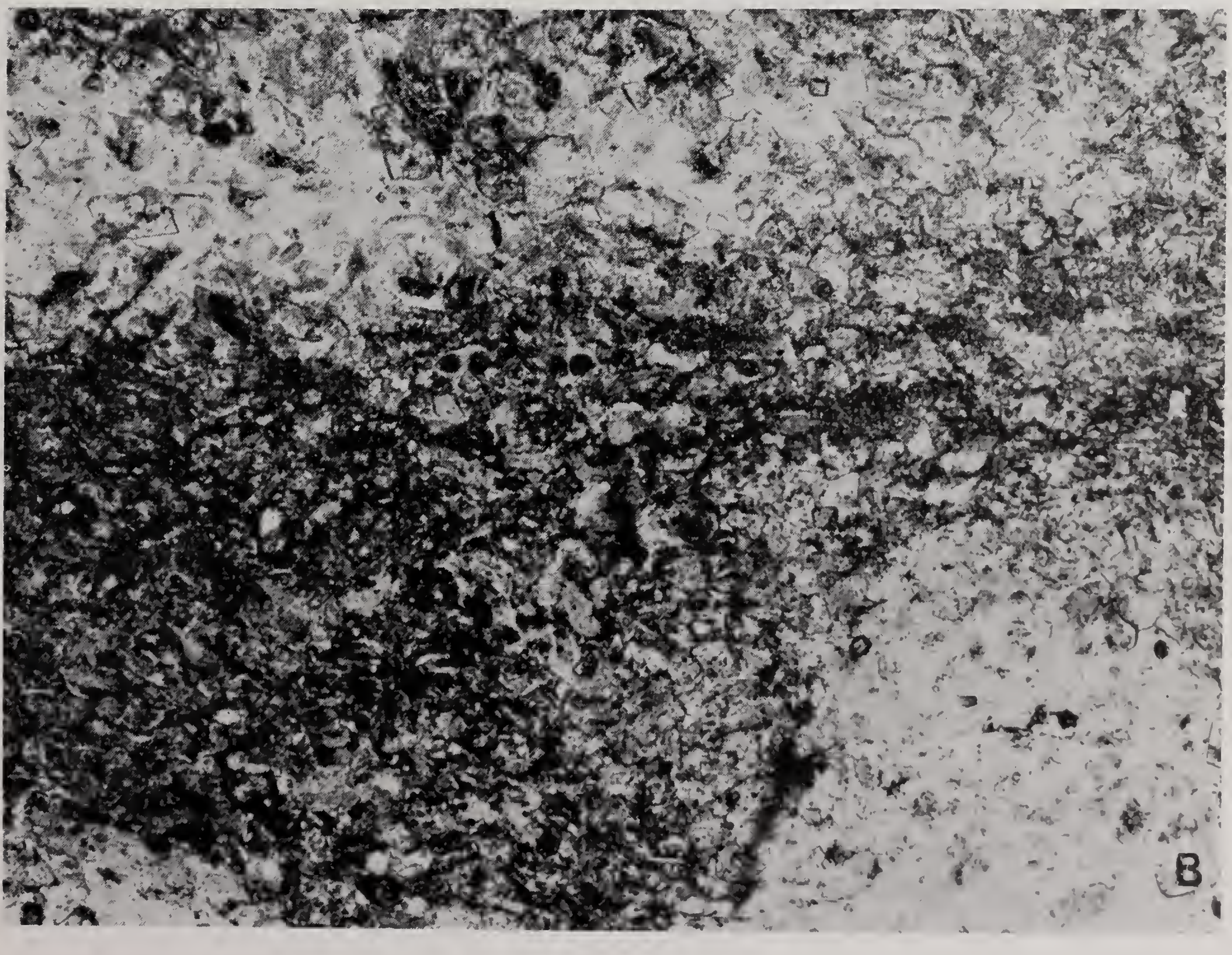
North of Jonesboro, the Mill Creek type of limestone interbedded with Kornthal-type limestone was noted in the E½ SW¼ NE¼ sec. 11, T. 12 S., R. 2 W., where the stone was at one time quarried in small quantities. A considerably greater thickness of the Mill Creek type of limestone, somewhat less coarse than usual, occurs at Tunnel Cut along the Gulf, Mobile and Ohio Railroad, about a mile south of Kaolin in the S½ SW¼ NW¼ sec. 2 of the same township where about 45 feet of limestone is exposed.

EXPLANATION OF PLATE 8

A.—This limestone is similar to that shown on plate 7 but is the fine-grained variety of Warsaw-Salem Limestone. Magnified 20 times.

B.—Photograph by transmitted light of a thin section of the fine-grained variety of Warsaw-Salem Limestone. The section is perpendicular to the bedding of the rock, which extends from left to right. Magnified 20 times. The dark area is dark gray limestone bordered by light areas of light gray limestone. The color of the dark areas is largely due to organic material. A rhomb-shaped crystal of dolomite is visible in the lower right-hand corner of the picture under the letter B and others occur at various places in the light gray area in the upper part of the photograph.


A


B

Thickness of Types

The maximum exposed thickness of the Mill Creek type of limestone observed without interbedded limestone of the Kornthal type was about 60 feet, noted in the quarry of the Jonesboro Stone Company. Roughly 45 feet of limestone also is exposed in Tunnel Cut near Kaolin. However, the diamond drilling of the Pure Limestone Company cut 329 feet and gaps in the core record as studied made it possible that the true thicknesses are even greater than this. However, this is believed to be a greater thickness than is normally present elsewhere in Alexander, Pulaski, and Union Counties, judging from outcrops and limited well data.

The Ullin quarry exposes more than 100 feet of interlayered Mill Creek and Kornthal types of limestone, and an abandoned quarry near Kornthal Church shows 28 feet of Kornthal-type limestone, although at one time 40 feet of stone is reported to have been visible at this general vicinity.

Results of Tests

A number of chemical analyses are given in table 3. Results of physical tests are reported in tables 6 and 7.

Uses

Mill Creek type of limestone.—The Mill Creek type of limestone probably is suitable for concrete aggregate, railroad ballast, road stone, and the like except in the area north of Mill Creek where it is in places too soft for such purposes. It is generally a high-calcium limestone, as indicated by the analysis of Sample NF 443, table 3, from the quarry of the Jonesboro Stone Company, Samples L 1 and NF 516 from Tunnel Cut, and NF 565 A, B, and C from the diamond drill core of the Pure Limestone Company. Its purity should suit it for a number of the uses of high-calcium limestone (p. 14), and also for use as a component in the raw mix used for portland cement manufacture.

The limestone appears streaked and banded due to alternate bands consisting principally of the coarse, dark gray calcite fragments and the fine-grained light gray or white bryozoan detritus. These characteristics and the fact that the stone takes a good polish have led to its use as decorative marble and building stone. Marble slabs cut at right angles to the bedding of the deposits have an interesting, clean looking, banded appearance, whereas slabs cut parallel to the bedding have an attractive, irregularly mottled texture. Large blocks of stone for sawing and polishing as marble are quarried by the Agatan Stone and Machinery Company of Dongola and the Lutz Marble Company of Anna, which also produce finished marble slabs as well as various types of cut stone and veneering stone. The stone probably would be suitable also for riprap and rubble.

The use of the Mill Creek type of limestone as a building stone is not new, for small, old quarries occur at a number of places that evidently served as sources of building stone. It can be seen in chimneys, foundations, and walls in Jonesboro and elsewhere, where it has given good service for many years. In addition to the gray stone currently in use, light buff stone is available from the upper weathered parts of some deposits.

Kornthal-type limestone.—The Kornthal type of limestone is generally harder than the Mill Creek type and some of it is less pure. The results of physical tests on chert-free samples indicate that the stone probably is suitable for concrete, road metal, railroad ballast, and the like. Samples W 285, NF 527, and NF 568 (table 3), indicate that the stone is of medium purity or locally may be high-calcium stone. It could be used for agricultural limestone, and its composition is such that much of it probably could be used in the raw portland cement mix.

Interbedded Mill Creek and Kornthal types of limestone.—Deposits composed of interbedded Mill Creek and Kornthal types of limestone normally share the characteristics of both types of stone. Except in

the area north of Mill Creek where the Mill Creek type of stone is likely to be soft, deposits composed of the two types of limestone probably can supply stone for concrete aggregate, road stone, and railroad ballast unless they are too cherty. Selected strata probably are suitable for riprap, rubble, various types of building stone, and for polishing as marble. The chemical composition for the mixed-type deposits varies. Some units are high-calcium limestone (Samples NF 451 A, 451 B, and 451 C, table 3), whereas others are somewhat less pure (Samples NF 451 D, 451 E, D 47 and L 10). The composition of much of the stone is such that some of it probably could be used in the mix for making portland cement.

HARDIN COUNTY

The Warsaw-Salem Limestone crops out in scattered places in a limited area around Hicks Dome in western Hardin County (pl. 2) and is estimated to be about 250 feet thick. Roughly, the lower 200 feet of the formation is fine-grained, dark gray to black limestone. Thin, black, shaly beds and partings and chert are present locally. The upper 60 to 80 feet of the formation is light to medium gray, medium to coarsely crystalline limestone. In some places this phase of the Warsaw-Salem may be absent.

The best exposures occur along a tributary of Hicks Branch in the western part of sec. 25, T. 11 S., R. 7 E. Sample NF 546 was taken from 32 feet of the dark lower part of the Warsaw-Salem exposed along the creek in the SW¼ SW¼ sec. 25. The outcrop from which the sample was taken occupied a vertical interval of 63 feet in which there were four covered areas totalling 31 feet thick. Of the limestone sampled, 9 feet was cherty, and the chert was included in the sample. The limestone is highly siliceous.

Probably much or parts of the Warsaw-Salem could be used for road rock and other purposes. Full evaluation of its possible uses, however, would involve test drilling to provide adequate samples of the unweathered limestone.

CLAY AND SHALE FORMATIONS AND THEIR CEMENT-MAKING POSSIBILITIES

It has been pointed out that clay or shale generally is one of the two principal components of the raw mix used for making portland cement, the other component being limestone. A number of geologic formations consisting of both limestone and shale have been described and attention called to the problem of maintaining a balance between the amounts of shale and limestone available from such formations so that there is not an excess of one or the other above requirements for cement.

Because of this problem it may be desirable to use a combination of relatively pure limestone from one deposit and shale or clay devoid, or largely devoid, of limy material from another. As such deposits are likely to be more uniform in composition than the strata in interbedded limestone and shale deposits, separate sources of raw materials may require less chemical control of the raw materials entering the mixture used.

It should be noted that when comparatively pure limestone is used with shale or clay in the raw mix, the silica, alumina, and iron oxide in the mix come principally from the shale or clay. Therefore, it is desirable that the silica ratio of the shale or clay be roughly between 2.0 and 3.0, as indicated under the discussion of portland cement. Table 2 gives the silica ratios for the clay and shale samples, analyses of which are given in table 4.

Most of the alkali in the cement raw mix also will come from the clay or shale when comparatively pure limestone is used. As mentioned earlier, the alkali content of the raw mix should generally not be more than about .6 percent, expressed as Na_2O equivalent. Data on alkali content of the clays and shales whose analyses are given in table 4 are given in table 2.

The proportioning of the raw materials in a portland cement raw mix involves factors other than those mentioned and should be determined by a specialist in cement making. Combining impure lime-

stones with calcareous shales particularly involves numerous complexities. Consequently, it is possible here merely to point out some of the general characteristics of the shales and clays that make them potentially usable in making cement.

Shales That Are Part of Limestone-Bearing Formations

A number of limestone-bearing formations have been described that include interbedded or associated shale. The amount of such shale varies in different formations and within the same formation, as does the chemical composition of the shales. General comments regarding these shales have been made in discussions of formations; chemical analyses are given in table 4.

The Alto, Bailey, Clore, Golconda, Glen Dean, Kinkaid, Menard, Moccasin Springs, Paint Creek, Renault, and Vienna Formations may be of suitable composition and character in some places to serve as sources of both limestone and shale for cement making, or of either limestone or shale alone for blending with raw materials from other deposits. Whether such deposits are economic sources of raw materials depends on many variables, including the relative amounts of shale and limestone constituting a specific deposit. Data on silica ratios and alkali content are given in table 2.

Shales and Clays Not Parts of Limestone-Bearing Formations

The following discussion relates to the principal clays and shales that do not occur as part of limestone-bearing formations in extreme southern Illinois. The relation of the clays and shales to the limestone formations is indicated in table 1.

The discussion gives a general idea of the occurrence, extent, and character of the clays and shales with the understanding that the suitability of any given clay or shale may vary from place to place and should be investigated by prospecting and further testing if it becomes of potential commercial importance. More detailed information regarding clay and shale resources of extreme southern Illinois appears in a report on that subject (Lamar, 1948). The clays and shales are described subsequently in alphabetical order.

Alluvial "clays"

The valley flats and related terraces of numerous southern Illinois streams, especially the Mississippi, Ohio, and Cache Rivers and Big Bay Creek, are underlain by gray or brown silty clay or clayey silt in many places. Exposures of these materials occur principally in drainage ditches. For convenience, and in keeping with common local usage, they are hereafter referred to as "clays." Chemical analyses of 6 samples are given in tables 4 and 5.

It is likely that large tonnages of these materials are present in some places. Many deposits probably become calcareous with depth.

Samples NF 569 and 570 represent 5 and 7 feet, respectively, of grayish brown or brownish gray clay along Clear Creek drainage ditch in Alexander and Union Counties. Their silica ratios are above the approximate maximum for cement-making clays (table 2). Sample NF 469 from a terrace silt deposit near Choat in Massac County shares the same characteristics.

Samples NF 571A, B, and C were taken from a cut along Post Creek Cutoff near Karnak in Pulaski County. The materials exposed and sampled were as follows:

	Thickness ft.
5. Soil, brown	½
4. Clay, calcareous, brown with red spots, a few small calcareous concretions. Sample NF 571C	2
3. Clay, black, very carbonaceous	1±
2. Clay, noncalcareous, very plastic, gray with brown and yellow areas. Sample NF 571B	5
1. Clay, calcareous, gray and brown. Sample NF 571A	3
Covered	

It appears possible that unit 3 above is a soil and that unit 4 is material that was dumped on top of the soil during the excavation of the cutoff. The silica ratio of all three samples is within the approximate range for cement-making clays (table 2).

Bailey Shale

See Moccasin Springs and Bailey Shale.

Cretaceous Age Clays

Clays of Cretaceous age occur at various places in the uplands of Alexander, Union, Pulaski, Massac, and Pope Counties, and especially in the general vicinity of Mountain Glen, Fayville, Unity, Pulaski, Grand Chain, Round Knob, Choat, and Boaz. The clays vary in color and composition, particularly in the amount of included quartz particles in the form of silt or sand. The clay mineral material in most of the clays is primarily a mixture of illite and kaolinite, except for certain deposits near Mountain Glen in Union County that are kaolinite only. Some deposits rest directly on an uneven bedrock surface, especially in Alexander and Union Counties, whereas others rest on silts or sand. Some clay beds are lenticular, others appear fairly extensive. Many natural outcrops show considerable slumping.

Excluding the kaolin deposits near Mountain Glen, the probable maximum thickness of most of the individual beds of Cretaceous age clays is less than 25 feet, but some deposits may contain a greater thickness of clay in the form of several beds separated by sand or silt. Many of the clay beds vary considerably in thickness from place to place.

Overburden on the Cretaceous age clay beds varies as to character and thickness. Many clay beds are overlain by sands or silts of Cretaceous age and/or younger brown chert gravel and red sand. Above these materials there is commonly 5 to 25 or more feet of loess.

The kaolin clay at Kaolin near Mountain Glen (Lamar, 1948, p. 23-29) is thought to occur mainly in depressions in the limestone bedrock of the area and commonly at or near the base of the ridges, and as accumulations on the flanks of the limestone ridges. Although deposits of clay as much as 87 feet thick have been reported, individual deposits are believed to be of limited extent. Considerable tonnages of clay were produced during World War I from this area for crucibles and glass pots.

Data on deposits sampled and chemical composition of the Cretaceous age clays are given in table 4. Samples AK, D10, D11, D12, D13, D14, and R 83 are kaolin.

Major problems in connection with the production of Cretaceous age clays for cement making include locating deposits having a reasonably consistent character, adequate thickness, and a sufficiently thin overburden to be workable. The silica ratio of many of the Cretaceous clay samples, excluding the kaolin, are within the approximate range for clays in cement making. The kaolin samples have too low a silica ratio to fall within these limits, principally because of their relatively high alumina content.

Clay in Devonian Rocks

The Devonian rocks in extreme southern Illinois are principally chert or very cherty limestone. However, at some places weathering or other agencies have produced deposits of tripoli or "amorphous" silica, and, in a few places, deposits of siliceous clay.

Some of the silica deposits contain clay as thin layers in such abundance that in the commercial operation of one deposit of this kind, near Olive Branch, separate grades of silica and "clay" were produced by hydraulic classification and sold commercially. A sample from a 6-inch deposit of clay along a fault exposed in a silica deposit in a silica mine contained 65.88 percent SiO_2, 23.86 percent Al_2O_3, and 0.65 percent Fe_2O_3.

In a few places nature has produced deposits of white clay containing scattered masses of chert, as in the NE¼ sec. 4, T. 15 S., R. 3 W., near Gale where a deposit 5 to 8 feet thick occurred in an underground mine. Also, a test pit in the valley flat of the Cache River in the SE¼ NE¼ SW¼ sec. 31, T. 15 S., R. 1 W., near Unity, is said to have encountered two beds of white clay, each 3 feet thick and separated by 6 inches of silica, overlain by 1½ feet of earth and silica. A boring in the same section penetrated 10 feet of clay at a depth of 8 feet. Sample D 44 was taken from this clay and its chemical analysis is given in table 4.

The extent of clay deposits like those described above is not known though they may well be small. Deposits of silica containing clay are thought likely to be more extensive.

These clays may bear consideration for certain special grades of cement, such as white portland cement, because their iron oxide content may be low.

Loess

The uplands of extreme southern Illinois are mantled by a brown clayey silt called loess, which ranges from a few to 50 feet and more thick. Analyses of samples, representing deposits from 10 to 48 feet thick in various parts of southern Illinois, are given in table 4.

Mineralogically the loess consists principally of quartz silt and fine-grained quartz sand with lesser amounts of clay material. Some deposits contain a small amount of calcium carbonate, commonly less than 10 percent. The silica ratio (table 2) of the samples analyzed ranges between 3.8 and 5.7. Iron oxide content is mostly between 3 and 5 percent and alkali is comparatively high. The samples tested were obtained from deposits near river flats. In general, the loess deposits distant from the major river valley flats probably are likely to contain more clay and hence have a greater alumina content than those near the river flats.

Moccasin Springs and Bailey Shale

The Moccasin Springs and Bailey Formations crop out in the general area east of Thebes in Alexander County. The upper part of the Moccasin Springs is a dark red or greenish shale that grades upward without a sharp line of separation into the lower part of the Bailey, which also is dark red, greenish, or gray shale. Earthy limestone strata are present in the lower part of the shale unit and cherty limestone beds in the upper part. The exact thickness of the combined shales is not known. It probably varies from place to place but may reach 90 feet.

A sample from 25 feet of gray-green shale in the upper part of the shale unit was collected along Horse Creek in the SW¼ NW¼ SW¼ sec. 23, T. 14 S., R. 3 W., east of McClure. The shale contains scattered limestone nodules. Another sample, L 62, represents 20 feet of shale along Orchard Creek in the E½ SW¼ SE¼ sec. 21, T. 15 S., R. 3 W., southeast of Thebes. Sample NF 528 had a magnesia content above the preferred limit for cement-making materials (tables 2, 4). Sample L 62 was within the limit. These data suggest that the shale varies in chemical composition.

Mountain Glen Shale

See New Albany Shale.

New Albany Shale

The New Albany Shale crops out in Union, Alexander, and Hardin Counties. In Union County, where it was formerly called the Mountain Glen Shale. The New Albany Shale underlies a narrow band mostly one-eighth to three-sixteenths of a mile wide beginning at a point about one and a quarter miles southwest of Jonesboro and extending north and a little west for about eight miles. It also crops out in the vicinity of Elco in Alexander County. The shale is well bedded, dark gray or black, carbonaceous, and has a maximum thickness of about 50 feet. One of the better outcrops occurs along a creek near Mountain Glen and other outcrops are present in the vicinity of Jonesboro. Sample NF 517 (table 4) was taken from the Mountain Glen exposure, Samples 10 and 11 along Caney Creek southeast of that place, and Sample 1 along Green Creek.

In Hardin County about seven miles north of Elizabethtown, the New Albany Shale underlies an oval-shaped band that is one-fourth to three-eighths of a mile wide and about two miles long. The shale is dark gray or black, carbonaceous, and is estimated to be about 400 feet thick. Outcrops are not extensive but the exposed shale is believed to be more siliceous than it is in Union County.

The silica ratio of three of the four samples of the shale is within the rough range for shale for cement making; the ratio of the third sample is above 3.0.

The presence of thick limestone formations in the general vicinity of the Union County deposits is significant. Thick limestone formations also are present in the general area of the shale outcrops in Hardin County but the deposits are relatively remote from rail or water transportation.

Orchard Creek Shale

The Orchard Creek Shale is calcareous and underlies limited areas near Gale and Thebes in Alexander County. The maximum observed thickness of the formation is 22 feet. Parts of the formation contain thin layers of limestone, especially the upper and middle parts.

Sample NF 523 (table 4), representing 9 feet of the shale near Thebes, contains roughly 48 percent calcium carbonate and has a silica ratio of 3.3 (table 2). Its possibilities for cement making are not known.

Pennsylvanian Shale

Rocks of Pennsylvanian age occur in the northern parts of Union, Johnson, Pope, and Hardin Counties. For the most part they are sandstone but in some places shales are present. Under usual conditions the shale deposits are likely to be overlain by sandstone. Many of the shales contain interbedded sandstone or are sandy but some of them are relatively free from these materials.

Sample NF 510 (tables 2, 4) was taken from a road-cut exposure of 21 feet of predominantly gray shale near Eddyville. The deposit probably is thicker than the 21 feet available for sampling. The outcrop sampled contained two beds of clayey sandstone totaling 11 inches thick. The analysis of the sample indicates that its composition is within the rough limits for a shale for a cement raw mix. The limestone-bearing formation commonly closest to the Pennsylvanian rocks is the Kinkaid, which itself includes deposits of shale.

Porters Creek Clay

The Porters Creek Clay underlies considerable areas in the vicinity of Olmsted, Villa Ridge, Mounds, and Unity. The upper part of the formation is worked at Olmsted. The formation, which is between 65 and 120 feet thick, consists of gray to dark gray clay that breaks with an irregular fracture into angular pieces and generally slakes little or not at all in water. It is comparatively light in weight. The silica ratios (table 2) of the two samples whose analyses are given in table 4 are 3 and 4.3.

Residual Clay

In some parts of southern Illinois, especially Union and Hardin Counties, limestone bedrock is locally overlain by a red clay that in many places contains pieces of chert. The clay is a residue left from limestone that has been leached of its carbonates by groundwater. The deposits of residual clay are of variable thickness and distribution. Many of them rest on a very uneven limestone floor. Twenty feet is the maximum thickness of residual clay observed, but locally it may be thicker.

Sample B 21 was taken from 7 feet of chert-free residual clay in Hardin County (tables 2, 4). The silica ratio of the sample is 1.8 and it has a high iron oxide content.

Springville Shale

The Springville Shale crops out in the uplands of western Union County and northeastern Alexander County. It is mainly brown or dull green, medium- to thick-bedded, and siliceous. The upper part of the formation is commonly more siliceous than the lower part and in some places is hard enough to resemble slate. Locally the shale is white, cream, or very light green and is mottled with pink, red, or purple blotches, for which reason it is sometimes called "calico" shale. The formation is about 60 feet thick.

The location of some of the better outcrops of the Springville Shale and the results of analyses of samples taken from them appear in table 4. The silica ratio of the six samples ranges between 4.7 and 6.4.

Clay of Uncertain Age

In the vicinity of Raum in Pope County there is a kind of clay unknown elsewhere in southern Illinois whose exact geological age is not known. The clay mineral composing the clay is halloysite. The extent

and thickness of the clay is not known. An analysis of the clay is given in table 4, Sample D 56, and shows it has a silica ratio of 2.1. Many years ago pottery clay was dug from the deposit.

RESOURCES BY COUNTIES

In the following pages the limestone resources of southern Illinois are briefly summarized and evaluated by counties. For the most part, the details already presented regarding specific formations are not repeated and reference should be made to earlier pages for such information. The terms "physical uses" and "high-calcium limestone" used hereafter have been discussed earlier in the report. Table 5 gives chemical analyses of limestones, shales, and clays. Other data relating to these materials are given in tables 1, 2, 6, and 7.

Alexander County

Alexander County (pl. 1) contains extensive deposits of cherty limestone and chert, but chert-free limestones are relatively limited. The thickest of the latter formations is the Kimmswick Limestone whose principal area of outcrop occurs in the banks of the Mississippi River and the adjacent uplands about a mile south of Thebes. The formation is between 100 and 150 feet thick and has scattered chert nodules in the upper portion. As indicated in the previous discussion of the formation, the limited area of the outcrop and its physical characteristics pose problems for open-pit quarrying, therefore production for large tonnages of stone might require underground mining.

Most of the formation is a high-calcium limestone and could no doubt be used for many of the purposes requiring this type of stone, although a sample taken south of Thebes was too soft for aggregate for portland cement concrete and higher types of bituminous road surfacing. The limestone is light gray, white or pink, has an attractive texture, takes a good polish, occurs in heavy beds, and might be used as a building stone or decorative marble.

The Girardeau Limestone crops out at a number of places in the vicinity of Thebes and has a maximum thickness of from 30 to 40 feet. It is a fine-grained, thin-bedded, dark gray limestone, somewhat siliceous, and contains a few scattered nodules of black chert. Most deposits have a heavy overburden except in the immediate vicinity of the outcrops. The limestone probably could be used for aggregate for concrete and bituminous roads, railroad ballast, road stone, agricultural limestone, and the like. Its thin-bedded character may favor its use for flagstones, and possibly rubble, if the color is satisfactory.

The Bainbridge Group crops out locally in western Alexander County (pl. 1) and includes about 20 to 25 feet of a lower formation of dark red limestone mottled with green, the St. Clair Limestone. A sample of this formation taken east of McClure was high-calcium limestone. Above this, the Moccasin Springs Formation is an impure red limestone overlain by red or greenish gray shale. The total thickness of the group probably is around 100 to 150 feet, but the thickness of the individual units is variable.

Tests on a sample of the St. Clair Limestone east of McClure showed it to be suitable for concrete aggregate and bituminous roads; it also is likely to be suitable for railroad ballast and road rock as well as for some of the uses of high-calcium limestone. The stone takes a polish and may have value as a decorative marble. The earthy limestone of the Moccasin Springs appears to have no particular use at present except as a possible part of a cement raw mix.

The Sexton Creek Limestone is present in western Alexander County where it lies beneath St. Clair strata. The formation as observed in outcrops east of McClure is cherty and therefore of uncertain commercial importance.

The Bailey Limestone is predominantly a cherty siliceous limestone. Another such formation is the Burlington-Keokuk Formation, which consists partly of chert and partly of siliceous limestone. There appears to be little present use for these cherty limestones, but they presumably could be used for fill rock and road stone if it were economical to quarry them.

A narrow geographic band, believed to be underlain by the Lingle and Alto Formations, occurs in the general vicinity of Elco. Exposures of the strata are few and their character is not well known. In Union County the formations are principally impure limestone, cherty limestone, and shale. Too little is known about the formations in Alexander County to permit discussion of their possible uses.

Portland Cement-Making Materials

The magnesia content of samples of the Kimmswick and St. Clair Limestones falls within the desired limit for cement-making materials. One sample of the Girardeau Limestone had a magnesia content slightly above the limit, another sample was within the limit. Sources of shale in the outcrop area of these formations are the Orchard Creek Shale and the shale in the upper part of the Moccasin Springs Formation. The latter shale is believed to grade upward, without a sharp line of separation, into shale in the lower part of the Bailey Formation.

The Orchard Creek Shale lies beneath the Girardeau Limestone and its greatest known thickness is 22 feet. The analysis of a sample reported in tables 2 and 5 shows a magnesia content acceptable for a cement-making material, but the silica ratio is above the rough maximum of 3.0. Exploration of the Orchard Creek Shale, however, might reveal deposits of shale of more suitable composition. The formation contains thin limestone strata.

The earthy limestone of the Moccasin Springs Formation, represented by Sample NF 524 (table 5), presumably would require the addition of purer limestone for cement making. However, its magnesia content lies within the limits for cement-making materials. The shale unit of the Moccasin Springs and Bailey Formations, represented by Sample NF 528, has a silica ratio above the rough limit; Sample L 62 was within the limits. It is possible that exploration may reveal other deposits of the earthy limestone of the Moccasin Springs that would be purer, and that combinations of these beds with the shale unit of the Moccasin Springs and Bailey Formations and the purer limestone of the St. Clair Formation could be worked out that would be within the composition limits for cement making.

Clays of Cretaceous age are found in the uplands of Alexander County in the general area east of Thebes. Known deposits generally have a considerable overburden. No deposits of Cretaceous age clays in Alexander County were sampled, but it is possible that some of them will fall within the range of cement-making materials.

The brown and locally gray silty clay, called loess, that mantles the uplands of Alexander County was sampled near Gale. Two samples, NF 513 and D 4, had silica ratios above the approximate maximum for cement-making clays, as did a number of other samples of loess taken at other places in southern Illinois. A sample of alluvial clay, NF 570, taken near McClure, also had a high silica ratio.

Hardin County

The two limestone-bearing formations in Hardin County having the greatest areal extent and thickness are the St. Louis and Ste. Genevieve. They occur near the Ohio River for a considerable distance and also underlie other parts of the county (pl. 2). The character of these two formations has been discussed previously. Chemical analyses are given in table 5 and the results of physical tests in tables 6 and 7. The Fredonia and Levias Limestones mentioned in table 5 are members of the Ste. Genevieve Formation.

Much of the Ste. Genevieve is oolitic limestone. Certain of the oolite beds are of high purity and suitable for some of the uses of high-calcium limestone (p. 14). They also are suitable for a variety of the physical uses of limestone, as are other non-cherty portions of the formation.

The St. Louis Limestone generally is not known to be a high-calcium limestone and much of the formation is cherty. Some of the non-cherty or less cherty parts may be suitable for agricultural limestone and a variety of the physical uses of limestone.

Of more limited extent than the two formations just described are the limestone of Devonian age and the Warsaw-Salem Limestone. The first of these underlies an area of about a square mile on Hicks Dome, about seven miles northwest of Elizabethtown. Outcrops are few and the nature of the limestone is not well known but it probably is cherty.

The Warsaw-Salem Limestone underlies an oval-shaped belt one-half to one mile wide around Hicks Dome. The strata include both the dark, cherty limestone composing the lower part of the formation and a lighter colored upper limestone. Possibly parts of the formation could be used for agricultural limestone and for some of the physical uses of limestone, but the existing outcrops do not provide an adequate basis for fully determining its possible uses.

Aside from the foregoing, there are six other formations that contain limestones in varying but lesser thicknesses than the formations mentioned above. The limestones, commonly associated with various thicknesses of shale, are the Renault, Golconda, Glen Dean, Menard, Clore, and Kinkaid Formations. The last formation may not be present everywhere in the area. The Paint Creek Formation also may contain a few thin strata of limestone but it is generally shale and/or sandstone.

Some of the six formations listed may contain high-calcium limestone locally, but in general they are probably not to be regarded as major sources of such stone. However, agricultural limestone, road material, and possibly concrete aggregate, may be available from parts of some of these formations to fulfill local demands.

Portland Cement-Making Materials

Portland cement-making materials are discussed separately inasmuch as both limestone and clay or shale are likely to be involved. The materials may come from separate deposits or from a single deposit containing both limestone and the clay or shale.

In the class of separate deposits, the Ste. Genevieve Formation seems to be a likely source of limestone. Analyses of samples representing limestone up to 80 feet thick that contains less than 3 percent magnesia are reported in table 5. There may be more than 80 feet of such stone in places. However, careful prospecting is necessary because some of the Ste. Genevieve is too high in magnesia to meet specifications, and other parts of the formation, especially the lower portion, are cherty and thus less desirable.

The St. Louis Limestone probably is generally higher in magnesia than the limestone of the Ste. Genevieve Formation. The data at hand indicate, however, that parts of the St. Louis may meet specifications. Considerable portions of the formations are cherty.

Because of their cherty character the limestone of Devonian age and part of the Warsaw-Salem Limestone are of uncertain value for cement making but it is possible that suitable stone may exist in places in the upper part of the latter formation.

A major type of clay in Hardin County is the brown, silty loess that mantles the uplands and is available in large quantities. An analysis of a sample of loess from a road cut near Rosiclare showed a silica ratio of 5.3, which is above the rough maximum for cement-making clay. The magnesia content is adequately low. It is possible that deposits with a lower silica-to-alumina ratio may occur, though four samples of loess from other parts of southern Illinois also had comparatively high ratios.

In some places where limestone is the bedrock, the loess rests on a deposit of reddish clay, the residue from solution of the limestone by groundwater. At many places the residual clay contains an abundance of chert fragments but in other places it is chert free, for instance near Eichorn where a sample (B 21) representing 7 feet of clay was obtained. The silica ratio for the sample was 1.8. Other samples may have a higher ratio. The residual clay deposits vary in thickness.

The New Albany is the thickest shale formation in Hardin County. It is dark gray to black shale and underlies a belt one-fourth to half a mile wide making an oval

tract with a maximum dimension of about two miles. The tract is on Hicks Dome about seven miles north of Rosiclare. Exposures of the shale are relatively uncommon; that which was noted appeared to be more siliceous than the black shale in Union County. It is possible that exploration may discover suitable deposits of New Albany Shale but the distance of the deposits from the Ohio River or from rail transportation at Rosiclare might prove a handicap.

Large blank areas in the north part of the Hardin County map (pl. 2) and smaller blank areas elsewhere on the map, are those underlain by rocks of Pennsylvanian age, principally sandstone. Sandstone also underlies many of the other areas shown as blank on the map. It is possible, however, that in some places shales are associated with the sandstone strata and may be thick enough and of such character as to meet chemical requirements of shale for use in cement making.

Hardin County also has single deposits from which both limestone and shale may be obtained, namely the six formations that consist of limestone and various amounts of interbedded shale. Analyses of samples from these limestones and associated shales from Hardin County and from other southern Illinois counties suggest that some of the limestones and shales may be of suitable composition for cement making. The Paint Creek Formation also contains considerable thicknesses of shale that may be usable for the same purpose.

A major problem is that of finding deposits that contain a reasonably consistent ratio of about 4 parts of limestone to 1 part of shale and have a chemical composition of reasonable constancy. Even though deposits may not be capable of supplying both limestone and shale, parts of some of them may be sufficiently shaly in some places to afford material for blending with limestone of the Ste. Genevieve and possibly of the St. Louis Formation.

Johnson County

Limestone deposits in Johnson County are limited to that part of the county roughly south of an east-west line through Goreville and Ozark (pl. 3). The thickest limestone in Johnson County is in the Ste. Genevieve Formation, which crops out in a comparatively small area in the southwest part of the county in the vicinity of Whitehill and Belknap. This formation is known to be 130 feet thick and probably is considerably thicker. Many beds of the limestone are oolitic. It has been discussed in some detail earlier in this report.

The Ste. Genevieve Limestone is the source of crushed stone for a variety of uses. The chemical composition of the formation varies considerably, as indicated by analyses in table 5. Some units of stone are comparatively high in magnesium carbonate but others are high-calcium limestone that may be suitable for a number of the chemical uses of limestone. Some of the stone contains less than 3.2 percent magnesium oxide and hence meets the magnesia specification for portland cement-making materials.

Much of Johnson County is underlain by a series of limestone-bearing formations that include various amounts of shale, either as comparatively thin beds interlayered with limestone strata or as thicker units. These are the Clore, Glen Dean, Golconda, Kinkaid, Menard, Paint Creek, and Renault Formations, all of which already have been individually described. The greatest thicknesses of limestone free of interbedded shale occur in the Kinkaid Formation, a deposit of which about 60 feet thick is being quarried at Buncombe for the production of various grades of crushed stone.

Next to the Kinkaid, the Menard Formation probably contains the thickest limestone units. The individual limestone beds in the other formations mentioned above may be thick enough to be quarried in a limited way at some places, but in general they commonly are not more than 25 feet thick.

Results of chemical analyses of samples are given in table 5 and of physical tests in tables 6 and 7. The data indicate that the formations vary in purity and that some deposits may be suitable for concrete aggre-

gate, road stone, agricultural limestone, and other purposes. Some of the samples tested meet the magnesia specifications for cement-making materials.

Portland Cement-Making Materials

As stated, samples representing considerable thicknesses of limestone of the Ste. Genevieve Formation and some of the limestone beds in the other formations have less than the allowable maximum of magnesia for making cement materials.

The Clore, Glen Dean, Golconda, Kinkaid, Menard, Paint Creek, and Renault Formations contain shale strata of various thicknesses interbedded with the limestone units of the formations. Analyses of some of these shales are given in table 5 and indicate that a number of the samples have magnesia and silica ratio values (table 2) within the limits for shale for cement making. A major problem as far as raw materials are concerned would be the location and proving up of economically workable deposits that have limestone and shale in a proper and reasonably consistent ratio and of adequately uniform composition.

Lying between the successive limestone formations in Johnson County are other formations consisting principally of sandstone. Sandstone is also the principal rock north of the area where limestones are shown in plate 3. In all these sandstone-bearing areas there is a possibility of local occurrences of shale. One shale sample from the Tar Springs Formation had a magnesia content and a silica ratio within the approximate limits set for cement-making materials.

The uplands of Johnson County commonly are mantled by a brown, silty clay called loess. No samples of this material from Johnson County were analyzed, but samples from other southern Illinois counties had a silica ratio above the approximate maximum for clay for cement making.

Massac County

The limestone resources of Massac County are limited to the north part of the county (pl. 4-A). The thickest limestone is in the Ste. Genevieve Formation, outcrops of which are limited to an area northwest of Mermet where comparatively low hills and ridges are underlain by the limestone. In one of these hills about a mile northwest of Mermet in the E½ E½ sec. 22, T. 14 S., R. 3 E., the Columbia Quarry Company operates a quarry. A hill about two miles north of Mermet in the center of sec. 15 in the same township is reported (Krey and Lamar, 1925, p. 273) to have exposed 28 feet of limestone. Two other areas north of Boaz are believed to be underlain by the limestone. Red clay residual from the leaching of the limestone rests on the stone in some areas; much of the clay is cherty.

In the vicinity of New Columbia and in the uplands south of Big Bay, outcrops of Renault, Paint Creek, Glen Dean, and Golconda Formations occur in the bluffs bordering the lowlands. These formations contain varying thicknesses of limestone interbedded with shale. An outcrop of the Renault Formation in the NE¼ NW¼ NW¼ sec. 3, T. 14 S., R. 3 E., consisted of 21 feet 2 inches of limestone with which was interbedded 12 feet 3 inches of shale. Results of chemical analyses of Samples NF 552 L (limestone) and NF 552 S (shale) are given in table 5. A physical test of the limestone is reported in table 6. The sample of limestone is not a high-calcium stone but could be used for agricultural limestone and for some of the physical uses of limestone if it could be economically separated and cleaned from the shale interbedded with it. Limestone beds in some of the other formations may be similarly useful.

Portland Cement-Making Materials

Although an analysis of limestone of the Ste. Genevieve Formation in Massac County is not at hand, it is probable that parts of the formation will meet chemical specifications for cement-making materials, judging from the character of the formation elsewhere in southern Illinois. Sample NF 552 L of limestone of the Renault Formation, mentioned above, is low in magnesia and also appears to have a suitable chemical composition. The Paint Creek, Glen Dean, and Golconda Forma-

tions also may contain acceptable limestones. The last four mentioned formations consist of interbedded limestone and shale, and, although deposits may occur that might serve as sources of either limestone or shale, it may be more desirable to obtain both materials from the same deposit if the shale and limestone are of suitable composition and are present in the required proportions.

A sample of shale, NF 552 S, from the same deposit as limestone Sample NF 552 L had a silica ratio within the approximate range for cement making.

Sources of clay in Massac County are the clays of Cretaceous age in the northern part of the county and the loess and other silty clays in many parts of the county. Six samples of Cretaceous age clays (tables 2, 5) included four samples whose silica ratio is within the rough range for clays and two samples that are above it. No samples of loess were taken from Massac County but, judging from the character of the loess elsewhere, the silica ratio may be too high to meet specifications. The same is likely to be true of the other types of silty clays in the county, such as Sample NF 469 taken near Choat.

Pope County

Those portions of central and northern Pope County likely to contain limestone deposits are shown in plate 5. South of an east-west line through Bay City the geology of the county has not been mapped in detail but enough is known about the area to provide a general idea of limestone possibilities.

The thickest limestone-bearing formation cropping out in Pope County is the Ste. Genevieve, which underlies a small, elongate area along the east county line (pl. 5). The formation also is said (Worthen, 1866, p. 438) to have cropped out at low water in the bed of the Ohio River near the mouth of Dog Creek in the SW¼ sec. 34, T. 15 S., R. 7 E., north of Hamletsburg in extreme southern Pope County. A small outcrop is visible in the north part of the town in the NW¼ NW¼ sec. 10, T. 16 S., R. 7 E. The extent of the limestone in the Hamletsburg area is not known.

The Ste. Genevieve Formation already has been described in this report. It may be around 200 feet thick. One sample taken in Pope County was impure limestone but purer beds probably are present that may have a variety of uses.

Much of Pope County is underlain by a series of limestone-bearing formations that include various amounts of shale, either as comparatively thin beds interlayered with limestone strata or as thicker units of shale. These are the Clore, Glen Dean, Golconda, Kinkaid, Menard, Paint Creek, and Renault Formations, all of which have been individually described.

The greatest thicknesses of limestone free of interbedded shale are believed to occur in the Kinkaid Formation, which has been quarried in a comparatively small way at a number of places, such as in Pine Hollow a few miles east of Dixon Springs.

Next to the Kinkaid, the Menard Formation probably contains the thickest limestone units. The individual limestone beds in the other formations may be thick enough to be quarried in a limited way at some places, but they are thought to be in general not more than 25 feet thick.

In that part of Pope County south of an east-west line through Bay City, outcrops of limestone have been reported in some places (Worthen, 1866, p. 442-47) along Barren Creek from the SW¼ sec. 35, T. 14 S., R. 6 E., upstream for some distance along Burke Creek in secs. 3, 4, and 5, T. 15 S., R. 6 E., on the north side of Dog Creek, probably in sec. 18, T. 15 S., R. 7 E., and in the valley walls of Alcorn Creek in parts of secs. 29, 31, and 32 in the same township. The specific limestone-bearing formations involved are not known but they are most likely to be the Renault, Paint Creek, Golconda, or Glen Dean Formations.

The results of chemical analyses of limestone samples are given in table 5 and results of a physical test of limestone of the Kinkaid Formation are given in table 6. The data indicate that the formations vary

in purity and that some deposits may be suitable for concrete aggregate, road stone, agricultural limestone, and other such purposes.

Portland Cement-Making Materials

The limestones of several Pope County formations (table 5) have less than the allowable maximum magnesia content for cement-making materials, and it is possible that the unsampled limestones in some of the other limestone-bearing formations in Pope County will be similar in this respect.

All of the formations mentioned above except the Ste. Genevieve contain, in strata of various thicknesses, shale interbedded with the limestone units of the formations. Analyses of three samples of shale from the Golconda Formation (tables 2, 5) were within the allowable magnesia and silica ratio limits for cement materials. Shales from the other limestone-bearing formations also may be within allowable limits.

Use of deposits of interbedded limestone and shale as sources of materials for cement making involves the location and proving of economically workable deposits that have a suitable ratio of limestone and shale and an adequately uniform composition.

Lying between the successive limestone formations in Pope County are other formations consisting principally of sandstone. Sandstone also is the principal rock of the blank areas of plate 5 except for the bottomland areas, especially those along Bay Creek and the Ohio River. In all these sandstone-bearing areas the occurrence of shale at some places is possible. One such sample from the Pennsylvanian rocks, NF 510, was within the magnesia limit for cement-making materials.

At some places in the uplands of Pope County south of Bay Creek, clays of Cretaceous age occur. Analyses of two samples of such clay are given in table 5. Their silica ratios are within the rough limits for cement-making clays. No data are at hand regarding their magnesia content but it is believed that it also may be within acceptable limits. The thickness and extent of the Cretaceous age clay deposits in the uplands is not known, although the individual clay beds are not likely to be more than 25 feet thick and commonly may be less. Most deposits are likely to have an overburden of loess, with or without brown chert gravel.

The uplands of Pope County commonly are mantled by silty loess. A sample of this material from Pope County had a silica ratio that was above the rough specifications for clay or shale for cement making. This appears to be a general characteristic of the loess in southern Illinois insofar as the samples taken indicate.

Pulaski County

Limestone deposits are limited to the north part of Pulaski County. The Burlington-Keokuk Formation, which consists of siliceous limestone and chert, underlies small areas in the vicinity of Ullin (pl. 4-B). A sample, NF 534, from 22½ feet of cherty limestone but with the chert omitted from the sample, was siliceous (table 5). The limestone probably could be used for road rock and fill stone.

The Warsaw-Salem Limestone underlies a considerable area north of Ullin, which is the site of a quarry operated by the Columbia Quarry Company for the production of various types of crushed stone. Analyses of seven samples from the present quarry and from an earlier one (table 5) indicate that the chemical composition of the stone varies but that considerable thicknesses are high-calcium limestone.

The uplands east of Wetaug and north of Perks are underlain by the St. Louis and Ste. Genevieve Formations. If suitable quarry sites are present the limestones probably can afford a source of stone suitable for some of the physical uses of limestone and possibly for some of the chemical uses.

Two small outcrops occur, one in the SE corner of sec. 2, T. 15 S., R. 2 E., on the shore of the Ohio River and the other in the bottom of Post Creek cutoff in the NE¼ SW¼ of the same section. The deposit on the Post Creek cutoff is of limited extent; that along the Ohio River also may be limited.

Portland Cement-Making Materials

Chemical analyses of samples of the Warsaw-Salem Limestone indicate that all samples tested are within the allowable magnesia limit for cement-making materials. Parts of the St. Louis and Ste. Genevieve Formations also may be within the limit. The Keokuk-Burlington is believed to be generally too cherty to be important.

No outcrops of shale are known in Pulaski County but a number of clays are available. The limestone deposits commonly are overlain by loess and some of them are capped by red clays, which are a residuum from the solution of the limestone. The loess, represented by Sample NF 496 (tables 2, 5) has a silica ratio above the approximate limit for clays of portland cement. The residual clays are of varying thickness and unknown extent but may be of suitable composition if their iron content is not too high. The bottomlands of the Cache River are underlain in some places by alluvial silty clay. Samples NF 571 A, B, and C, taken near Karnak, indicate the clay's character.

More remote from the limestone deposits are the clays of Cretaceous age that occur in many places in the uplands of Pulaski County south of Cache River, especially in the general vicinity of Grand Chain and Pulaski (tables 2, 5). The Porters Creek Clay crops out near Olmsted, where it is worked commercially, and to a lesser extent near Villa Ridge, Mounds, and Unity. Analyses indicate a comparatively high silica ratio. In a few places clays generally similar to the Cretaceous age clay overlie the Porters Creek Clay.

In the SW¼ sec. 31, T. 15 S., R. 1 W., a white clay associated with chert and silica, probably derived by weathering from Devonian bedrock, was found in test pits. An analysis of a sample of that clay indicates that its silica ratio exceeds the rough limits for cement-making clays.

Union County

Union County contains many limestone formations of diverse character. Because of their extent, thickness, and composition, the Warsaw-Salem, St. Louis, and Ste. Genevieve Formations appear to be of greatest general commercial importance, although other formations also may be important at some places. Plate 6 shows the distribution and general character of the formations; chemical analyses and the results of physical tests are given in tables 5, 6, and 7. All three of the formations mentioned are 150 or more feet thick, and at some places are near, or relatively accessible to, railroad transportation or paved roads.

The Ste. Genevieve Formation contains beds of oolite of high purity up to 20 feet or more thick that probably would be suitable for some of the uses of high-calcium limestone. These strata are likely to be more prevalent in the upper part of the formation than in the lower. Most of the limestone is suitable for many of the physical uses of limestone. Deposits containing considerable chert, more likely to be in the lower part of the formation, would be of less extensive use.

The St. Louis Limestone is generally not high-calcium limestone. Parts of the formation are cherty and some strata are comparatively impure. However, it seems probable that careful exploration would reveal workable thicknesses of stone that would be suitable for many of the physical uses of limestone. In general the St. Louis Limestone is believed to occur in thinner beds than most of the limestone of the overlying Ste. Genevieve and the underlying Warsaw-Salem Formations.

The Mill Creek type of limestone of the Warsaw-Salem Formation is generally of high purity and would be suitable for a number of the uses of high-calcium limestone. Some of it is too soft for such purposes as concrete aggregate and railroad ballast. The stone is used as commercial marble and building stone, purposes for which it is well suited because it occurs in thick beds, has pleasing color and texture, is easily worked, and is weather resistant. It is also quarried for agricultural limestone.

The Kornthal type of limestone of the Warsaw-Salem Formation is locally of high purity and may be suitable for some of the uses of this type of stone. Much of the lime-

stone is harder than that of the Mill Creek type and so can be used for many of the physical uses of limestone, including building and decorative stone. Chert in some deposits limits their chemical or physical uses.

Two other formations in Union County are known to contain high-calcium limestone, the Backbone and Grand Tower Limestones (pl. 6).

The Backbone Limestone is well exposed in the valley walls of Hutchins Creek in northwestern Union County. Another outcrop occurs in the Mississippi River bluff at Rattlesnake Ferry in Jackson County about 1½ miles north of the Union County line. Thirty feet, and possibly more, of high-calcium limestone occurs in places in the Backbone Limestone, but other parts of the formation are cherty. The Grand Tower Limestone does not crop out extensively but 22 feet of high-calcium limestone was noted near Mountain Glen and the thickness of such limestone may be greater than this.

A sample taken from 23½ feet of the St. Clair Limestone in Alexander County was high-calcium limestone. The same formation crops out in two comparatively small areas east of Reynoldsville, but it is not known whether high-calcium limestone of significant thickness occurs in these areas.

Of uncertain economic value at present are the cherty or highly siliceous limestones of the Bailey, Burlington-Keokuk, Clear Creek, Sexton Creek, and parts of the Backbone Formations (pl. 6). Stone from these formations possibly could be used for making fills, road foundations, or road rock.

A number of other limestone-bearing formations—the Alto, Clore, Glen Dean, Golconda, Kinkaid, Lingle, Paint Creek, and Vienna—crop out in Union County. Most of the limestones are associated with shale or clay, and the thickness of the shale-free limestone is generally less than 50 feet and often less than 25 feet. As a rule the limestones are not high-calcium stone but some deposits are sufficiently pure to be used for agricultural limestone. These and other deposits also might supply stone for a number of physical uses.

Portland Cement-Making Materials

Raw materials for portland cement making are discussed separately because they include both limestone and shale. These raw materials (p. 15) may be obtained either from separate deposits of limestone and shale or from deposits that combine both materials. In the former case, the principal shale formations are the Springville and New Albany (Mountain Glen) Formations, with others possibly present in some Pennsylvanian strata. The Springville Shale overlies the New Albany Shale and together they underlie the area shown as white on plate 6, between the tracts mapped as Warsaw-Salem and Burlington-Keokuk and those shown as Lingle, Alto, and Meisenheimer. Further details of the distribution of the shales are given in a report by Weller and Ekblaw (1940) and they have been described herein in some detail.

The analyses at hand of the Springville Shale have comparatively high silica ratios (tables 2, 5) but conceivably some parts of the formation, such as the greenish shale west of Springville, may have lower ratios. Three of four samples of the New Albany Shale have silica ratios below the rough maximum.

Geographically the Grand Tower, Warsaw-Salem, St. Louis, and Ste. Genevieve Formations are close to the areas underlain by the New Albany Shale in the vicinity of Jonesboro. Samples from these formations, except the St. Louis, appear to be of suitable composition for cement making. However, it is likely that some parts of the St. Louis also will be suitable. South of Jonesboro the Warsaw-Salem and St. Louis Formations are relatively near the areas believed to contain the New Albany and Springville Shales.

Pennsylvanian rocks, and to a lesser extent alluvium, underlie the area shown as blank portions on plate 6, north of the area occupied by the Kinkaid Formation. The rocks are mainly sandstone but shale is present in some places and many of the shales are sandy. No shales of Pennsylvanian age in Union County were tested

but some of them may be suitable for making cement. The closest source of limestone for combining with the shales is the Kinkaid Formation. The magnesium oxide content of one sample of limestone from the Kinkaid Formation in Union County was above the limit for making cement but it is possible that other parts of the formation, or the formation at other places in the county, may have acceptable composition.

The Cretaceous age clays in the Mountain Glen area have a relatively low silica ratio but possibly could be used for making cement in combination with other raw materials of suitable character.

Loess is general throughout Union County and occurs as overburden on many limestone deposits. The loess samples from southern Illinois all have a silica ratio above the rough limit for cement but it may be that some deposits, or parts of them, can be found that will be sufficiently high in clay mineral content to reduce this ratio to a lower figure. The same applies to the alluvial clays. Sample NF 569 was taken from a deposit of such clay near Ware.

In roughly the northeast half of Union County the Renault, Paint Creek, Golconda, Glen Dean, Menard, Vienna, Clore, and Kinkaid Formations (pl. 6) contain limestone and shale in varying thicknesses. The composition of some of the limestones and some of the shales is likely to meet specifications for cement-making materials. Some of the formations mentioned contain considerable thicknesses of clay or shale, as do some of the formations consisting primarily of sandstone that intervene between the limestone formations mentioned above. Some of these shales might prove to be a source of shale for cement making along with some of the thicker limestones mentioned above.

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Table 2.—Silica Ratio and Alkali Content of Clays and Shales

Sample No.	County	Silica ratio	Alkali content (percent)*
		Alluvial Clays	
NF 469	Massac	7.3	.89
NF 569	Union	5.9	2.07
NF 570	Alexander	4.2	2.29
NF 571A	Pulaski	2.6	2.40
NF 571B	Pulaski	3.0	2.34
NF 571C	Pulaski	2.6	2.47
		Moccasin Springs—Bailey Shale	
NF 528	Alexander	3.5	2.43
L 62	Alexander	2.3	2.61
		Cretaceous Clay	
D 32	Massac	2.8	—
D 28	Massac	2.8	—
D 29	Massac	3.6	—
D 30	Massac	2.3	—
D 31	Massac	3.4	—
D 50	Massac	2.7	—
B 4	Pulaski	2.1	—
D 45	Pulaski	2.5	—
D 46	Pulaski	2.0	—
D 33	Pulaski	2.9	—
D 36	Pulaski	3.0	—
D 34	Pope	2.5	—
D 35	Pope	2.4	—
AK	Union	1.4	.56
D 10	Union	1.0	—
D 11	Union	1.5	—
D 12	Union	1.8	—
D 13	Union	1.2	—
D 14	Union	1.5	—
R 83	Union	1.5	.11
		Clay in Devonian Rocks	
D 44	Pulaski	3.3	—
		Golconda Shale	
BU 21	Pope	2.2	—
BU 22	Pope	2.1	—
BU 23	Pope	2.2	—
NF 535S	Union	2.2	1.05
NF 515S	Union	3.5	.88
		Kinkaid Shale	
NF 478D	Johnson	2.6	2.14
NF 478E	Johnson	2.6	2.67
NF 545A	Saline	2.2	2.91
		Loess Clay	
NF 513	Alexander	5.7	3.10
DS 4	Alexander	3.8	—
NF 559	Hardin	5.3	2.05
NF 264	Pope	4.6	2.51
NF 496	Pulaski	5.2	2.73
L 10	Union	3.8	—

TABLE 2.—(Continued)

Sample No.	County	Silica ratio	Alkali content (percent)*
		Menard Shale	
T 2	Johnson	2.6	—
T 4	Johnson	2.4	—
		New Albany Shale	
10	Union	2.4	3.8
11	Union	2.7	3.4
NF 517	Union	3.6	3.05
1	Union	2.9	3.34
		Orchard Creek Shale	
NF 523	Alexander	3.3	1.92
		Pennsylvanian Shale	
NF 510	Pope	2.8	2.32
		Porters Creek Clay	
La 3	Pulaski	4.3	.92
FE 116	Pulaski	3.0	1.01
		Renault Shale	
NF 551S	Johnson	3.3	1.83
NF 552S	Massac	2.4	1.99
L 11	Union	2.6	—
		Residual Clay	
B 21	Hardin	1.8	1.34
		Springville Shale	
NF 514A-1	Union	6.4	1.72
NF 514A-2	Union	4.9	2.38
W 286	Union	5.2	—
LM 14	Union	5.7	2.01
NF 413	Union	5.4	1.89
NF 541	Union	4.7	2.62
		Tar Springs Shale	
NF 554S	Johnson	2.1	2.73
		Vienna Shale	
NF 520	Johnson	2.3	1.59
		Clay of uncertain age	
D 56	Pope	2.1	—

*Expressed as Na_2O equivalent.

Table 3.—Chemical Analyses of Southern

Sample number	County	Location T.-R.	sec.	¼	¼	¼	Near	Thickness (ft.)	(in.)	Date†	Remarks
							Backbone Limestone				
NF 536 (10-38)	Jackson	10S-3W	27	—	W½	SW	Howardton	29		1955[1]	Mississippi River bluff south of Rattlesnake Ferry
NF 444	Union	11S-3W	23	NE	SW	NE	Wolf Lake	40		1946[2]	Bluff of Hutchins Creek
							Bailey Limestone				
NF 530	Alexander	15S-2W	19	SW	NW	SW	Olive Branch	11	4	1955[1]	Limestone portion of an outcrop that contains 6′ 1″ of chert and shale
NF 91	Union	11S-3W	4	N½	SW	SE	Aldridge	45		1933[7]	Lower 45′ in river bluff
NF 92	Union	11S-3W	4	N½	SW	SE	Aldridge	50		1933[7]	Upper 45′ in river bluff
La 7	Union	11S-3W	21	—	—	NE	LaRue	60		1933[7]	
NF 70	Union	12S-3W	3	SE	NW	NW	Wolf Lake	60		1933[7]	
NF 93	Union	13S-2W	20	C	N½	N½	Reynoldsville	30		1933[7]	Lower 30′ in river bluff
NF 94	Union	13S-2W	20	C	N½	N½	Reynoldsville	100		1933[7]	Upper 100′ in river bluff
							Burlington-Keokuk Formation				
NF 534	Alexander	14S-1W	22	NW	SE	NW	Ullin	22	6	1955[1]	About 10% of chert in deposit not included in sample
							Girardeau Limestone				
NF 512	Alexander	15S-3W	21	SW	SE	NW	Thebes	19	6	1955[1]	Outcrop at Rock Springs
L 37	Alexander	15S-3W	21	SW	SE	NW	Thebes	25		1928[5]	At Rock Springs
							Glen Dean Formation				
NF 554L	Johnson	13S-3E	17	NE	NE	NE	Vienna	20		1956[1]	Abandoned quarry; overlain by NF 554S, Tar Springs Shale
							Golconda Formation				
W 308	Johnson	13S-3E	16	—	C	W½	Vienna	30		1912[3]	May have interbedded shale
Bu 20	Pope	13S-6E	26	—	—	SE	Golconda	50		1912[3]	Limestone in an outcropping of 100′ or more of limestone and shale
W 319	Pope	13S-7E	19	—	—	—	Golconda	15		1912[3]	Bluff just north of Golconda
NF 515L	Union	11S-2W	25	S½	NE	SE	Mountain Glen	7	9	1955[1]	Limestone in 13½-foot exposure; balance of outcrop is shale, see Sample NF 515S
NF 535L	Union	13S-1E	2	NE	NW	SE	West Vienna	8	6	1955[1]	Limestone in 49′ 5″ exposure; balance of outcrop is shale, see NF 535S
							Grand Tower Limestone				
NF 457	Union	11S-2W	34	NW	NW	NE	Mountain Glen	22		1951[1]	Road cut
							Kimmswick Limestone				
NF 522A	Alexander	15S-3W	17	SE	NW	SE	Thebes	13	6	1955[1]	Railroad cut
NF 522B	Alexander	15S-3W	20	NW	NE	NE	Thebes	14	6	1955[1]	Bank of Mississippi River
L 57	Alexander	15S-3W	17	—	—	SE	Thebes	22		1928[2]	
L 58	Alexander	15S-3W	17	—	—	SE	Thebes	28		1928[2]	
L 63A	Alexander	15S-3W	17	—	—	SE	Thebes	20		1928[2]	
NF 450	Alexander	15S-3W	17	SE	NW	SE	Thebes	26		1949[2]	
							Kinkaid Formation				
NF 478A	Johnson	12S-2E	15	NE	SW	NE	Buncombe	18	4	1955[1]	S. Illinois Stone Co. 0 to 18′ 4″ above base of quarry
NF 478B	Johnson	12S-2E	15	NE	SW	NE	Buncombe	21		1955[1]	S. Illinois Stone Co. 18′ 4″ to 39′ 4″ above base of quarry
NF 478C	Johnson	12S-2E	15	NE	SW	NE	Buncombe	19	1	1955[1]	S. Illinois Stone Co. 39′ 4″ to 53′ 5″ above base of quarry
K 29	Johnson	12S-3E	16	—	—	—	Bloomfield	—		1925[4]	
Wills 1-6	Johnson	12S-4E	23	E½	SW	NE	Simpson	9		1950[2]	Abandoned quarry
NF 556A	Johnson	12S-4E	23	N½	SW	NE	Simpson	10	4	1956[1]	Limestone in 12′ 7″ of stone; old Wills quarry
NF 556B	Johnson	12S-4E	23	N½	SW	NE	Simpson	2	3	1956[1]	Limestone and shale interbedded with NF 556A
NF 556C	Johnson	12S-4E	23	N½	SW	NE	Simpson	17		1956[1]	Limestone below NF 556 A & B
DS 24	Pope	12S-5E	19	—	NW	SE	Robbs	5		1934[7]	Associated with shale. Railroad cut
NF 550	Pope	13S-5E	14	SW	SW	NE	Dixon Springs	29		1956[1]	Pine Hollow quarry
NF 545D	Saline	10S-7E	3	SE	SW	NW	Somerset	20		1956[1]	Cave Hill quarry; shale Sample NF 545A from same deposit
NF 532	Union	11S-1E	20	SE	NW	SE	Lick Creek	19		1955[1]	Abandoned quarry

Illinois Limestones Arranged by Formation

Sample number	$CaCO_3$	$MgCO_3$	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	R_2O_3	Na_2O	K_2O	CO_2	Ignition loss	Other components
Backbone Limestone													
NF 536 (10–38)	95.37*	3.62*	53.44	1.73	.98	.37	.19	—	.02	.03	43.56	43.46	SrO–.014
NF 444	95.98*	3.78*	53.77	1 81	0 68	.30	.10	—	.09	.04	43.61	43.60	SO_3–.04; MnO–.030; P_2O_5–.009
Bailey Limestone													
NF 530	47.95*	3.72*	26 87	1 78	42 80	3.38	1.19	—	.06	.79	21.38	23.18	
NF 91	54.20*	4.81*	30.37	2.30	37.25	3.21	1.12	—	—	—	—	25.48	
NF 92	47.86*	5.89*	26.82	2.82	41.44	3.93	1.10	—	—	—	—	23.47	
La 7	58.14	4.75	32.58*	2.27*	33.58	1.03	1.21	—	—	—	28.05	—	
NF 70	56.22*	6.06*	31.5	2.9	36.3	2.18	1.42	—	—	—	—	26.7	
NF 93	61.66*	3.45*	34.55	1.65	31.53	2 96	1.07	—	—	—	—	27.99	
NF 94	59.27*	6.06*	33.21	2.90	31.81	2.64	1.74	—	—	—	—	28.35	
Burlington-Keokuk Formation													
NF 534	78 06*	5 98*	43.74	2.86	15.19	.74	.22	—	.03	.08	36.82	37.16	
Girardeau Limestone													
NF 512	80.70*	6.80*	45.22	3.25	9.41	1.85	.64	—	.03	.45	38.30	38.89	MnO–.056; P_2O_5–.065; SO_3–.29; SrO–.048
L 37	90.86	4.80	50.82*	2 20*	3.72	1.40		—	—	—	—	—	
Glen Dean Formation													
NF 554L	91.39*	1.84*	51.21	.88	4.13	1.06	1.19	—	.03	.10	40.85	41.31	
Golconda Formation													
W 308	95 57	1 55	53 56	0 74	96	1.76		—	—	—	—	—	
Bu 20	88 75*	1.94*	49 74	0 93	7 66	2.02		—	—	—	—	39 85	
W 319	86.43	3 34	48.44	1 60	7 04	2.36		—	—	—	—	40.46	
NF 515L	75.80*	2.64*	42 48	1 26	17 07	3.44	1 08	—	.05	.57	33.62	34.73	
NF 535L	89.53*	1.67*	50 17	.80	6.12	1 37	1.03	—	.05	.12	40.03	40.37	
Grand Tower Limestone													
NF 457	97.56*	1.63*	54 67	.78	1 09	.28	.11	—	.02	.03	43.20	43 32	MnO–.024; P_2O_5–.017; SO_3–.09
Kimmswick Formation													
NF 522A	99.60*	.61*	55 81	.29	.15	.20	.09	—	.01	.01	43.67	43.61	MnO–.036; P_2O_5–.087; SO_3–.02; SrO–.018
NF 522B	99.53*	.84*	55.77	.40	.14	.20	.09	—	.01	.01	43.73	43.57	MnO–.048; P_2O_5–.094; SO_3–.05; SrO–.015
L 57	97.44	0.38	54.61*	.18*	.20	.10	.25	—	—	—	—	—	
L 58	96.90	0.60	54.30*	.29*	.90	.36	.10	—	—	—	—	—	
L 63A	98.54	0.55	55 22*	.26*	.32	.32	.10	—	—	—	—	—	
NF 450	99.69*	.71*	55 86	.34	.16	.20	.09	—	.06	.01	43 53	43.44	MnO–.038; P_2O_5–.034; TiO_2–nil
Kinkaid Formation													
NF 478A	69.62*	9.35*	39.01	4.47	14.68	3.07	1.27	—	.12	.60	34.39	35.76	MnO–.016; P_2O_5–.081; SO_3–1.28; SrO–.050
NF 478B	65.08*	11.52*	36.47	5.51	20.01	1.23	.76	—	.09	.20	34.18	34.70	MnO–.012; P_2O_5–.083; SO_3–.78; SrO–.044
NF 478C	69.15*	4.77*	38.75	2.88	17.65	4.31	1.29	—	.09	.99	32.32	33.48	MnO–.030; P_2O_5–.084; SO_3–.70; SrO–.051
K 29	91.45	3.10	51.25*	1.48*	4.74	.74		—	—	—	—	—	
Wills 1–6	87 21*	3.76*	48.87	1.80	6.56	1 44	.73	—	.11	.24	39.64	39.90	TiO_2–.10; MnO–.032; P_2O_5–.030
NF 556A	90.16*	2.64*	50.52	1.26	5.36	1 23	.95	—	.03	.10	40.55	41.02	
NF 556B	60.09*	12.80*	33.67	6.12	18.29	5 13	2 01	—	.17	.80	32.39	34.09	
NF 556C	89.39*	3.49*	50.09	1.67	5.52	1 40	.64	—	.06	.17	40.69	40.92	
DS 24	86.52	3.85	48.47	1.87	6.79	1.47	1.18	—	—	—	39.25	39.55	
NF 550	76.01*	2.55*	42.59	1.22	17.82	2.14	.73	—	.07	.41	34.19	34.86	
NF 545D	86.54*	2.13*	48.49	1.02	8.61	1.57	.76	—	.07	.26	38.63	39.21	
NF 532	85.13*	7.42*	47.70	3.55	4.43	1.18	1.25	—	.03	.20	41.05	41.46	

Table 3.—

Sample number	County	Location T.-R.	sec.	¼	¼	¼	Near	Thickness (ft.	in.)	Date†	Remarks
							Menard Formation				
NF 558A	Johnson	12S-2E	27	SE	NW	SE	West Vienna	16	11	1956[1]	Limestone in 26' of stone
NF 558C	Johnson	12S-2E	27	SE	NW	SE	West Vienna	9	1	1956[1]	Shale interbedded with NF 558A
T 1	Johnson	13S-4E	1	—	NE	SW	Flatwoods	7		1926[5]	South portal Flatwoods tunnel; 0 to 7' above base of cut
T 3	Johnson	13S-4E	1	—	NE	SW	Flatwoods	33		1926[6]	South portal Flatwoods tunnel; interbedded limestone and shale 11' to 44' above base of cut
T 5	Johnson	13S-4E	1	—	NE	SW	Flatwoods	34		1926[5]	South portal Flatwoods tunnel; limestone in 40' of interbedded limestone and shale: 44' to 84' above base of cut
D 48	Pope	13S-5E	31	—	—	SW	Reevesville	32		1912[3]	Location corrected
W 311	Pope	13S-5E	31	—	—	SW	Reevesville	50		1912[3]	Location corrected. Deposit has shale partings
NF 531	Union	11S-1W	36	NE	NW	NW	Saratoga	22		1955[1]	Outcrop in gully; three covered intervals
							Moccasin Springs Formation				
NF 524	Alexander	15S-3W	22	SE	SE	SW	Thebes	15		1955[1]	In creek bed
							Paint Creek Formation				
L 20	Union	12S-1W	8	—	N½	NE	Anna	18		1928[2]	
							Renault Formation				
NF 555A	Hardin	12S-7E	35	SW	NE	SW	Shetlerville	8	5	1956[1]	Old quarry; lower Renault Limestone
NF 176C	Hardin	12S-7E	35	—	E½	SW	Shetlerville	12	7	1934[2]	39' 11" to 52' 6" above base of exposure
NF 176D	Hardin	12S-7E	35	—	E½	SW	Shetlerville	5	4	1934[2]	52' 6" to 57' 10" above base of exposure
NF 551L	Johnson	14S-2E	1	NE	NW	SE	¼ mi. NE of Belknap	19	6	1956[1]	Belknap quarry; 19½' limestone in 32½' interbedded limestone and shale; see also shale
NF 560	Johnson	13S-3E	32	SE	SE	SW	Indian Point	13	5	1956[1]	Railroad cut
NF 552L	Massac	14S-3E	3	NE	NW	NW	Forman	21	2	1956[1]	21' 2" limestone in an exposure of 34' 5" of limestone and shale in an old quarry
							St. Clair Limestone				
NF 449	Alexander	14S-3W	12	SW	SE	NW	McClure	23	6	1949[5]	Basal 24½' of formation
							St. Louis Limestone				
NF 508A	Hardin	12S-9E	23	—	NE	NW	Cave in Rock	22	6	1954[1]	Abandoned quarry; upper two benches
NF 508B	Hardin	12S-9E	23	—	NE	NW	Cave in Rock	22	8	1954[1]	Abandoned quarry; two middle benches
NF 508C	Hardin	12S-9E	23	—	NE	NW	Cave in Rock	13	4	1954[1]	Abandoned quarry; lower bench
NF 529	Union	12S-1W	18	—	NE	SW	Anna	31		1955[1]	From two outcrops separated by a 25' covered zone
NF 533	Union	13S-1W	17	Center			St. John's church	17		1955[1]	Road cut
							Ste. Genevieve Formation (Fredonia Member)				
NF 177A	Hardin	12S-7E	35	S½	N½	SE	Shetlerville	16	6	1934[2]	P. R. Brown Stone Co.; 0 to 16' 6" above base
NF 177B	Hardin	12S-7E	35	S½	N½	SE	Shetlerville	22	1	1934[5]	P. R. Brown Stone Co.; 16' 6" to 38' 7" above base
NF 177C	Hardin	12S-7E	35	S½	N½	SE	Shetlerville	32	5	1934[5]	P. R. Brown Stone Co.; 38' 7" to 72' 10"
NF 177D	Hardin	12S-7E	35	S½	N½	SE	Shetlerville	11	4	1934[2]	P. R. Brown Stone Co.; 72' 10" to 84' 2"
Kx**	Hardin	12S-7E	35	—	—	—	Shetlerville	—		1925[4]	Outcrops in Rich Hill
NF 548A	Hardin	12S-8E	14	Center		SE	Elizabethtown	23		1956[1]	Road cut along Route 146
NF 548B	Hardin	12S-8E	14	—	NE	SE	Elizabethtown	11	6	1956[1]	Road cut along Route 146
NF 548C	Hardin	12S-8E	14	NE	NE	SE	Elizabethtown	40	3	1956[1]	Road cut along Route 146
W 322**	Hardin	12S-8E	27	—	—	SW	Elizabethtown	50		1912[3]	
NF 511A	Hardin	12S-8E	27	NE	SW	SW	Elizabethtown	28	6	1955[1]	J. L. Bean Stone Co.; 6' to 34½' below top of quarry
NF 511B	Hardin	12S-8E	27	NE	SW	SW	Elizabethtown	17		1955[1]	J. L. Bean Stone Co.; 34½' to 51½'
NF 511C	Hardin	12S-8E	27	NE	SW	SW	Elizabethtown	22	6	1955[1]	J. L. Bean Stone Co.; 51½' to 74'
NF 454A	Hardin	12S-9E	12	NE	NW	NW	Cave in Rock	38	4	1951[2]	Okerson quarry; 1' 8" to 40' above base
NF 454B	Hardin	12S-9E	12	NE	NW	NW	Cave in Rock	12	4	1951[2]	Okerson quarry; 43' 9" to 56' 1"
NF 454C	Hardin	12S-9E	12	NE	NW	NW	Cave in Rock	13	4	1951[2]	Okerson quarry; 56' 1" to 69' 5"
NF 454D	Hardin	12S-9E	12	NE	NW	NW	Cave in Rock	15	2	1951[2]	Okerson quarry; 72' 5" to 87' 7"
NF 453A	Hardin	12S-9E	12	NE	NE	NW	Cave in Rock	9	7	1951[2]	Rigsby & Barnard quarry; 0 to 9' 7" above base
NF 453B	Hardin	12S-9E	12	NE	NE	NW	Cave in Rock	14	5	1951[2]	Rigsby & Barnard quarry; 9' 7" to 24'
NF 453C	Hardin	12S-9E	12	NE	NE	NW	Cave in Rock	10	7	1951[2]	Rigsby & Barnard quarry; 24' to 34' 7"
NF 453D	Hardin	12S-9E	12	NE	NE	NW	Cave in Rock	12	7	1951[2]	Rigsby & Barnard quarry; 36' 11" to 49' 6"
NF 453E	Hardin	12S-9E	12	NE	NE	NW	Cave in Rock	14	5	1951[2]	Rigsby & Barnard quarry; 49' 6" to 63' 11"
NF 453F	Hardin	12S-9E	12	NE	NE	NW	Cave in Rock	16	7	1951[2]	Rigsby & Barnard quarry; 63' 11" to 80' 6"

(Continued)

Sample number	$CaCO_3$	$MgCO_3$	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	R_2O_3	Na_2O	K_2O	CO_2	Ignition loss	Other components
Menard Formation													
NF 558A	87.02*	2.11*	48.77	1.01	8.36	1.55	.66	—	.06	.16	38.85	39.30	
NF 558C	78.08*	2.01*	43.75	.96	12.82	3.83	2.17	—	.04	.43	34.40	36.27	
T 1	87.29*	3.74*	48.90	1.53	5.50	3.19	1.53	—	—	—	—	—	
T 3	58.43*	8.34*	32.74	3.99	20.90	7.12	3.32	—	—	—	—	—	
T 5	77.50*	5.71*	43.42	2.73	12.30	1.53	1.79	—	—	—	—	—	
D 48	87.32	2.65*	48.88	1.28	10.45	1.14		—	—	—	—	—	
W 311	87.72	2.47*	49.16	1.18	7.90	2.74		—	—	—	—	40.08	
NF 531	92.34*	2.64*	51.74	1.26	3.46	.87	.67	—	.06	.07	41.60	41.81	
Moccasin Springs Formation													
NF 524	69.62*	2.91*	39.01	1.39	19.42	5.15	1.93	—	.05	1.64	30.59	32.00	
Paint Creek Formation													
L 20	87.56*	4.00*	49.03	1.91	7.34	.42	.64	—	—	—	—	—	
Renault Formation													
NF 555A	83.72*	1.88*	46.91	.90	12.33	1.31	.46	—	.04	.26	37.45	37.78	
NF 176C	81.68*	2.94*	45.77	1.41	13.17	2.16	.72	—	—	—	36.51	36.80	
NF 176D	94.99*	2.99*	53.23	1.43	1.95	.11	.81	—	—	—	42.53	42.47	
NF 551L	88.55*	3.43*	49.62	1.64	6.47	1.31	.52	—	.12	.13	39.96	40.36	
NF 560	93.05*	2.13*	52.14	1.02	3.53	1.04	.79	—	.30	.08	41.29	41.69	
NF 552L	91.16*	1.92*	51.08	.92	5.23	1.06	.46	—	.04	.15	40.54	41.06	
St. Clair Limestone													
NF 449	95.00*	1.44*	53.23	.69	2.82	.90	.35	—	.04	.22	41.95	41.99	TiO_2–.13; MnO–.044; P_2O_5–.005
St. Louis Limestone													
NF 508A	71.81*	14.55*	40.24	6.96	13.04	.66	.21	—	.03	.08	38.64	38.82	
NF 508B	84.29*	5.02*	47.23	2.40	10.38	.63	.16	—	.04	.09	39.07	39.23	
NF 508C	81.39*	14.39*	45.61	6.88	3.75	.76	.26	—	.03	.12	42.47	42.87	
NF 529	85.95*	10.29*	48.16	4.92	3.44	.64	.20	—	.03	.07	42.53	42.85	
NF 533	68.19*	11.29*	38.21	5.40	18.79	1.23	.40	—	.03	.16	35.38	35.60	
Ste. Genevieve Formation (Fredonia Member)													
NF 177A	98.28*	1.08*	55.07	.52	1.13	.51	.31	—	—	—	42.57	43.15	P_2O_5–.020; MnO–0.02; SO_3–.07
NF 177B	99.58*	.23*	55.80	.11	.59	.32	.26	—	—	—	43.47	43.42	P_2O_5–.009; MnO–.008; SO_3–.15
NF 177C	88.80*	5.10*	49.76	2.44	4.84	1.59	1.04	—	—	—	41.25	41.03	
NF 177D	95.49*	3.28*	53.51	1.57	1.73	.54	.56	—	—	—	42.93	42.81	
Kx**	83.20	8.31	46.63*	3.97*	5.54	—	—	2.41	—	—	—	—	
NF 548A	85.86*	9.89	48.11	4.73	4.03	.39	.26	—	.03	.06	42.42	42 54	
NF 548B	91.53*	2.03*	51.29	.97	6.70	.50	.12	—	.03	.05	40 66	40 76	
NF 548C	76.10*	13.38*	42.64	6.40	9.09	.96	.43	—	.03	.16	40.17	40 26	
W 322**	80.43	7.56	45.08	3.62	9.10	2.14		—	—	—	—	40.18	
NF 511A	70.85*	16.40*	39.70	7.84	10.76	1.16	.62	—	.04	.24	38.78	39.58	MnO–.014; P_2O_5–.076; SO_3–.20; SrO–.061
NF 511B	89.55*	4.41*	50.18	2.11	5.37	.72	.18	—	.03	.09	40 66	41.39	MnO–.007; P_2O_5–.066; SO_3–.12; SrO–.082
NF 511C	93.28*	2.55*	52.27	1.22	3.60	.44	.21	—	.03	.07	42 09	42.11	MnO–.006; P_2O_5–.064; SO_3–.12; SrO–.078
NF 454A	91.39*	5.90*	51.21	2.82	2.12	.54	.31	—	.14	.06	42 85	43.07	P_2O_5–.035
NF 454B	92.98*	2.40*	52.10	1.15	3.91	.65	.26	—	.14	.11	41.76	42.02	P_2O_5–.043
NF 454C	81.79*	4.83*	45.83	2.31	10.41	1.89	.75	—	.19	.42	37.97	38.61	P_2O_5–.067
NF 454D	92.39*	3.68*	51.77	1.76	2.89	.88	.42	—	.18	.20	42.10	42.45	P_2O_5–.038
NF 453A	90.57*	7.09*	50.75	3.39	1.34	1.00	.27	—	.08	.06	43.09	43.34	P_2O_5–.023
NF 453B	98.47*	1.13*	55.18	.54	.03	.63	.13	—	.07	.03	43.51	43.74	P_2O_5–.010
NF 453C	95.73*	1.46*	53.64	.70	1.73	.97	.31	—	.10	.11	42.57	42.68	P_2O_5–.017
NF 453D	92.37*	2.36*	51.76	1.13	3.86	1.11	.29	—	.11	.13	41.45	41.78	P_2O_5–.031
NF 453E	82.23*	5.58*	46.08	2.67	8.86	2.17	.67	—	.24	.36	38.57	39.12	P_2O_5–.053
NF 453F	96.07*	1.99*	53.83	.95	1.77	.51	.25	—	.20	.06	42.75	43 08	P_2O_5–.029

Table 3.—

Sample number	County	Location T.–R.	sec.	¼	¼	¼	Near	Thickness (ft. in.)	Date†	Remarks
							Ste. Genevieve Formation (Fredonia Member)—continued			
W 330	Hardin	13S–8E	5	—	—	SW	Rosiclare	37	1912[3]	
D 16**	Johnson	14S–2E	1	—	—	—	Belknap	18	1912[3]	
D 17**	Johnson	14S–2E	1	—	—	—	Belknap	15	1912[3]	
NF 175A	Johnson	14S–2E	5	—	SW	SW	Whitehill	10 2	1934[2]	Charles Stone Co.; 0 to 10′ 2″ above base
NF 175B	Johnson	14S–2E	5	—	SW	SW	Whitehill	24 5	1934[2]	Charles Stone Co.; 10′ 2″ to 34′ 7″
NF 175C	Johnson	14S–2E	5	—	SW	SW	Whitehill	11 2	1934[2]	Charles Stone Co.; 34′ 7″ to 45′ 9″
NF 175D	Johnson	14S–2E	5	—	SW	SW	Whitehill	56 4	1934[2]	Charles Stone Co.; 45′ 9″ to 102′ 1″
NF 175E	Johnson	14S–2E	5	—	SW	SW	Whitehill	25 5	1934[2]	Charles Stone Co.; 102′ 1″ to 127′ 6″
W 304**	Johnson	14S–2E	5	—	—	—	Whitehill	60	1912[3]	
W 320**	Pope	11S–7E	22	—	SW	SE	Hicks	15	1912[3]	Limestone has shale partings
NF 174A	Union	12S–1W	20	SE	NW	NE	Anna	7 4	1934[2]	Anna Quarries, Inc.; 0 to 7′ 4″ above base
NF 174C	Union	12S–1W	20	SE	NW	NE	Anna	25 10	1934[2]	Anna Quarries, Inc.; 20′ 6″ to 46′ 4″
NF 174E	Union	12S–1W	20	SE	NW	NE	Anna	26 3	1934[2]	Anna Quarries, Inc.; 49′ 6″ to 75′ 9″
							Ste. Genevieve Formation (Levias Member)			
NF 176A	Hardin	12S–7E	35	—	E½	SW	Shetlerville	10 7	1934[2]	12′ 4″ to 22′ 11″ above base of exposure
NF 176B	Hardin	12S–7E	35	—	E½	SW	Shetlerville	17	1934[2]	22′ 11″ to 39′ 11″ above base of exposure
NF 555CD	Hardin	12S–7E	35	SW	NE	SW	Shetlerville	8 6	1956[1]	Lower part of old quarry
							Sexton Creek Limestone			
NF 525L	Alexander	14S–3W	27	SE	SW	SW	Gale	36	1955[1]	Deposit cherty; chert not included in this sample
							Vienna Formation			
NF 521	Johnson	13S–4E	12	SW	SW	NE	Grantsburg	20 4	1955[1]	Chert in deposit not included in sample
L 100	Johnson	13S–4E	12	—	—	E½	Grantsburg	20	1928[5]	
							Warsaw-Salem Formation			
NF 546	Hardin	11S–7E	25	—	SW	SW	Hicks	32	1956[1]	32′ of limestone in a 63-foot section, 31′ of section covered
NF 451D	Pulaski	14S–1W	14	SE	SW	NE	Ullin	21	1949[1]	Columbia Quarry Co.; 80′ to 101′ above quarry floor
NF 451A	Pulaski	14S–1W	14	SE	SW	NE	Ullin	14	1949[2]	Columbia Quarry Co.; 66′ to 80′ above quarry floor
NF 451B	Pulaski	14S–1W	14	SE	SW	NE	Ullin	25	1949[2]	Columbia Quarry Co.; 41′ to 66′ above quarry floor
NF 451C	Pulaski	14S–1W	14	SE	SW	NE	Ullin	41	1949[1]	Columbia Quarry Co.; 0 to 41′ above quarry floor.
NF 451E	Pulaski	14S–1W	14	SE	SW	NE	Ullin	35 8	1951[1]	Columbia Quarry Co.; 0 to 36′ below quarry floor mentioned above
D 47	Pulaski	14S–1W	14	—	—	—	Ullin	40	1912[3]	Lower 40′ in old quarry
L 10	Pulaski	14S–1W	14	—	SW	NE	Ullin	40	1928[5]	
NF 516	Union	12S–2W	2	SE	SW	NW	Kaolin	39	1955[1]	Cut along G.M. and O. R.R.
L 1	Union	12S–2W	2	—	—	W½	Kaolin	60	1928[2]	Tunnel cut
NF 443	Union	13S–1W	17	NE	SW	SW	Mill Creek	50	1946[2]	Jonesboro Stone Co.
NF 568	Union	13S–1W	18	SW	SW	NW	Mill Creek	22	1957[1]	Road cut
NF 565A	Union	13S–1W	20	SW	SW	SE	Mill Creek	100	1954[1]	Diamond drill core, Pure Limestone Co.; 78′ to 177′ deep
NF 565B	Union	13S–1W	20	SW	SW	SE	Mill Creek	100	1954[1]	Pure Limestone Co.; 178′ to 278′
NF 565C	Union	13S–1W	20	SW	SW	SE	Mill Creek	100	1954[1]	Pure Limestone Co.; 278′ to 378′
NF 565D	Union	13S–1W	20	SW	SW	SE	Mill Creek	29	1954[1]	Pure Limestone Co.; 378′ to 408′
NF 565E	Union	13S–1W	20	SW	SW	SE	Mill Creek	26	1954[1]	Pure Limestone Co.; 420′ to 446′
W 285	Union	13S–2W	1	—	NE	SE	Kornthal Station	40	1912[3]	Scattered chert nodules
NF 527	Union	13S–2W	1	NW	NE	SE	Kornthal Church	28	1955[1]	Abandoned quarry; chert present, not included in sample

†Date when sample was taken; if sampling date is not known, the date given is that of the publication of the analysis.
*Data calculated from other data in the analysis.
**Identity of beds uncertain, but probably Fredonia.
[1]Analysis made by L. D. McVicker in laboratories of Illinois State Geological Survey.
[2]Lamar, J. E., 1957, Chemical analyses of Illinois limestones and dolomites: Illinois Geol. Survey, Rept. Inv. 200.
[3]Bleininger, A. V., Lines, E. F., and Layman, F. E., 1912, Portland cement resources of Illinois: Illinois Geol. Survey Bull. 17, p. 97-100.

(Continued)

Sample number	$CaCO_3$	$MgCO_3$	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	R_2O_3	Na_2O	K_2O	CO_2	Ignition loss	Other components
Ste. Genevieve Formation (Fredonia Member)													
W 330	85.82	2.21	48.10	1.06	7.78	4.10		—	—	—	—	39.72	
D 16**	90.17	3.65	50.53*	1.75	6.00	1.32		—	—	—	—	—	
D 17**	93.11	2.01	52.18*	.96	5.38	.83		—	—	—	—	—	
NF 175A	82.40*	13.78*	46.17	6.59	3.18	.81	.46	—	—	—	42.99	42.71	
NF 175B	94.39*	1.53*	52.89	.73	3.51	.57	.35	—	—	—	42.43	42.00	
NF 175C	65.82*	21.21*	36.32	10.14	13.78	2.03	.66	—	—	—	37.06	37.67	
NF 175D	97.10*	2.42*	54.41	1.16	1.44	.37	.28	—	—	—	43.42	43.09	SO_3–.22
NF 175E	88.84*	3.74*	49.78	1.79	6.81	1.46	.64	—	—	—	39.24	40.19	
W 304**	94.07	3.14	52.72	1.50	2.04	1.22		—	—	—	—	—	
W 320**	70.52	1.76	39.52	.84	18.06	8.86		—	—	—	—	33.72	
NF 174A	97.30*	1.33*	54.52	.64	1.07	.50	.29	—	—	—	43.28	43.06	
NF 174C	93.10*	5.44*	52.17	2.60	1.82	.68	.33	—	—	—	43.69	43.04	
NF 174E	93.98*	4.83*	52.65	2.31	2.10	.45	.33	—	—	—	43.32	42.94	
Ste. Genevieve Formation (Levias Member)													
NF 176A	50.54*	3.93*	28.32	1.88	39.07	6.28	1.54	—	—	—	22.48	22.76	
NF 176B	94.10*	3.12*	52.73	1.49	2.43	.25	.78	—	—	—	42.31	42.30	
NF 555CD	92.07*	1.82*	51.59	0.87	4.59	1.38	.53	—	.08	.15	41.15	41.39	
Sexton Creek Limestone													
NF 525L	94.71*	2.01*	53.07	.96	3.59	.78	.26	—	.02	.17	41.89	41.90	
Vienna Formation													
NF 521	74.86*	7.99*	41.95	3.82	14.10	1.48	1.98	—	.06	.16	36.75	36.97	
L 100	75.52	7.49	42.29*	3.58*	13.02	0.57	1.33	—	—	—	—	—	
Warsaw-Salem Formation													
NF 546	55.70	3.20	31 21	1.53	37.93	1.82	.42	—	.15	.34	25.55	26.66	
NF 451D	93.51*	3.05*	52.40	1.46	4.00	.43	.13	—	.03	.03	41.15	41.47	
NF 451B	96.31*	2.49*	53.97	1.19	1.71	.18	.08	—	.01	.06	42.91	43.90	TiO_2–0.00; MnO–.002; P_2O_5–.055; SO_3–.14
NF 451A	97.58*	1.86*	54.68	.89	1.12	.20	.07	—	.00	.05	42.31	43.14	TiO_2–0.00; MnO–.002; P_2O_5–.045; SO_3–.11
NF 451C	97.23*	1.74*	54.48	.83	1.19	.33	.09	—	.02	.02	43.22	43.19	
NF 451E	93.60*	3.30*	52.45	1.58	2.67	.45	.10	—	.02	.04	42.65	42.70	
D 47	92.90	1.92	52.06*	.92	6.38	0.49		—	—	—	—	—	
L 10	94.72	1.50	53.04*	.72*	1.66	.35	.23	—	—	—	—	—	
NF 516	97.33*	1.71*	54.54	.82	1.36	.19	.09	—	.03	.02	43.25	43.18	MnO–.008; P_2O_5–.046; SO_3–.03; SrO–.034
L 1	96.70	.73	54.15*	.35*	.72	.20	.10	—	—	—	—	—	
NF 443	99.10*	1.46*	55.53	.70	.29	.26	.11	—	.07	.02	43.42	43.23	MnO–.005; SO_3–.15; P_2O_5–.046
NF 568	95.99*	3 66*	53 79	1 75	.76	.31	.12	—	—	—	—	43.61	
NF 565A	98.83*	.86*	55.38	.41	.42	.31	.09	—	.02	.02	43.51	43.66	MnO–.005; P_2O_5–.025; SO_3–.08
NF 565B	98.99*	1.25*	55.47	.60	.36	.29	09	—	.03	.02	43.66	43.68	MnO–.004; P_2O_5–.036; SO_3–.06
NF 565C	95.71*	4.35*	53.63	2.08	.58	.17	.09	—	.02	.02	43.79	43.84	MnO–.005; P_2O_5–.041; SO_3–.07
NF 565D	90.60*	8.22*	50.77	3.93	1.20	.57	.15	—	.02	.03	43.49	43.78	
NF 565E	88.91*	8.14*	49.82	3.89	2.98	.37	.13	—	.02	.03	42.67	42.98	
W 285	92.46	2.97	51.82	1.42	3.30	1.48		—	—	—	—	42.32	
NF 527	96.78*	2.17*	54.23	1.04	1.37	.35	.27	—	.02	.02	43.16	43.21	

[4]Krey, Frank, and Lamar, J. E., 1925, Limestone resources of Illinois: Illinois Geol. Survey Bull. 46, p. 312-33.
[5]Lamar, J. E., Machin, J. S., Voskuil, W. H., and Willman, H. B., 1956, Preliminary report on portland cement materials in Illinois: Illinois Geol. Survey Rept. Inv. 195, p. 28-31.
[6]Analysis by Chemistry Department, University of Illinois.
[7]Lamar, J. E., Willman, H. B., Fryling, C. F., and Voskuil, W. H., 1934, Rock wool from Illinois mineral resources: Illinois Geol. Survey Bull. 61, p. 118, 61.

TABLE 4.—CHEMICAL ANALYSES OF CLAYS AND SHALES

Sample number	County	Location T.-R.	sec.	¼	¼	¼	Near	Thickness sampled (ft.)	(in.)	Date*	Remarks
							Alluvium				
NF 469	Massac	15S–4E	27	NE	NW	SW	Choat	8		1952[1]	
NF 569	Union	12S–2W	32	SW	SE	NW	Ware	5		1957[1]	
NF 570	Alexander	14S–3W	12	NW	SE	NW	McClure	7		1957[1]	
NF 571A	Pulaski	14S–2E	26	SW	SE	SE	Karnak	3		1957[1]	Lower part of exposure
NF 571B	Pulaski	14S–2E	26	SW	SE	SE	Karnak	5		1957[1]	Middle part of exposure
NF 571C	Pulaski	14S–2E	26	SW	SE	SE	Karnak	2		1957[1]	Upper part of exposure
							Cretaceous Clay				
D 32	Massac	14S–5E	33	—	—	SE	Round Knob	4		1907[6]	
D 28	Massac	15S–4E	1	—	—	SW	Round Knob	6		1907[6]	
D 29	Massac	15S–4E	2	—	N½	SW	Round Knob	—		1907[6]	
D 30	Massac	15S–4E	2	—	N½	SW	Round Knob	6		1907[6]	
D 31	Massac	15S–4E	2	—	N½	SW	Round Knob	7	6	1907[6]	
D 50	Massac	16S–6E	12	—	—	—	Unionville	2		1907[6]	
B 4	Pulaski	14S–2E	27	—	SW	SW	Grand Chain	13		1948[7]	Outcrop and boring
D 45	Pulaski	15S–1W	15	—	—	—	Pulaski	9		1907[6]	
D 46	Pulaski	15S–1W	15	—	—	—	Pulaski	5		1907[6]	
D 33	Pulaski	15S–2E	1	—	—	—	Yates Landing	8		1907[6]	
D 36	Pulaski	15S–2E	18	—	—	—	Dam 53	—		1907[6]	
D 34	Pope	14S–5E	26	—	—	—	Rosebud	3		1907[6]	
D 35	Pope	14S–5E	26	—	—	—	Rosebud	2		1907[6]	
AK	Union	11S–2W	35	NE	SW	NW	Kaolin	—		1948[7]	Sample from storage bin of Boyd pit
D 10	Union	11S–2W	35	—	—	—	Kaolin	34		1907[6]	More than 50′ below surface
D 11	Union	11S–2W	35	—	—	—	Kaolin	4		1907[6]	40′ to 44′ below surface
D 12	Union	11S–2W	35	—	—	—	Kaolin	5		1907[6]	35′ to 40′ below surface
D 13	Union	11S–2W	35	—	—	—	Kaolin	—		1907[6]	From stock crib; yellowish
D 14	Union	11S–2W	35	—	—	—	Kaolin	—		1907[6]	From stock crib; white
R 83	Union	11S–2W	35	—	—	—	Kaolin	—		1933[5]	Purified by sedimentation
							Clay in Devonian Rocks				
D 44	Pulaski	15S–1W	31	—	—	—	Unity	10		1907[6]	Boring in flat of Cache River
							Golconda Shale				
Bu 21	Pope	13S–6E	26	—	—	—	Golconda	5	6	1912[3]	
Bu 22	Pope	13S–6E	26	—	—	—	Golconda	5	6	1912[3]	
Bu 23	Pope	13S–6E	26	—	—	—	Golconda	6	6	1912[3]	
NF 515S	Union	11S–2W	25	S½	NE	SE	Mountain Glen	4	8	1955[1]	Shale with interbedded limestone in 13½′ exposure; balance of outcrop limestone. See Sample NF 515L
NF 535S	Union	13S–1E	2	NE	NW	SE	Mt. Pleasant	40	11	1955[1]	Shale with limestone lenses in 49′ 5″ exposure; balance of outcrop limestone. See Sample NF 535L
							Kinkaid Shale				
NF 478D	Johnson	12S–2E	15	NE	SW	NE	Buncombe	7		1952[1]	Overburden at Southern Illinois Stone Co.
NF 478E	Johnson	12S–2E	15	NE	SW	NE	Buncombe	5	9	1952[1]	Southern Illinois Stone Co. overburden
NF 545A	Saline	10S–7E	3	SE	SW	NW	Somerset	10		1956[1]	Part of same deposit as limestone sample NF 545D
							Loess				
NF 513	Alexander	14S–3W	33	NE	NE	SW	Gale	25	6	1955[1]	Upper 6′ and lower 19½′ of loess exposed in borrow pit
DS 4	Alexander	15S–3W	4	NW	SE	NW	Gale	48		1948[7]	Road cut
NF 559	Hardin	12S–8E	30	SE	SE	NW	Rosiclare	10		1956[1]	Road cut
NF 264	Pope	13S–6E	24	SE	SW	NE	Golconda	20		1957[1]	Road cut
NF 496	Pulaski	16S–1W	7	SW	SW	SW	Unity	20		1957[1]	
L 10	Union	12S–1W	17	—	—	—	Anna	—		1912[2]	
							Menard Shale				
T 2	Johnson	13S–4E	1	—	NE	SW	Flatwoods	4		1926[4]	7′ to 11′ above base of cut, south portal of tunnel
T 4	Johnson	13S–4E	1	—	NE	SW	Flatwoods	6		1926[3]	44′ to 84′ above base of cut, south portal of tunnel; shale in 40′ interbedded limestone and shale
							Moccasin Springs-Bailey Shale				
L 62	Alexander	15S–3W	21	E½	SW	SE	Thebes	20		1958[1]	
NF 528	Alexander	14S–3W	23	SW	NW	SW	McClure	25		1957[1]	Contains limestone nodules

Arranged Alphabetically by Name

Sample number	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	CO_2	Ignition loss	Other components
Alluvium											
NF 469	83.76	—	9.53	1.92	.35	.47	.46	.65	.05	2.62	
NF 569	79.23	—	10.63	2.74	.59	.78	.91	1.76	.06	2.95	
NF 570	72.79	—	13.45	3.79	1.14	1.25	.90	2.11	.13	4.04	
NF 571A	52.39	—	14.87	5.16	3.92	8.02	.43	2.99	8.43	12.23	
NF 571B	67.07	—	17.12	5.19	.31	.97	.62	2.61	.12	5.41	
NF 571C	58.95	—	16.86	5.44	2.75	4.43	.52	2.95	4.17	8.67	
Cretaceous Clay											
D 32	64.88	1.26	21.54	1.86	—	—	—	—	—	6.83	Moisture–2.58
D 28	66.04	1.60	22.00	1.60	—	—	—	—	—	6.81	Moisture–1.64
D 29	71.58	1.40	18.31	1.51	—	—	—	—	—	5.27	Moisture–1.41
D 30	60.50	1.40	22.52	3.84	—	—	—	—	—	7.52	Moisture–3.44
D 31	69.46	1.64	18.82	1.32	—	—	—	—	—	5 31	Moisture–1.13
D 50	63.32	.48	19.25	4.09	—	—	—	—	—	6.02	Moisture–3.55
B 4	59.60	.72	26.48	2.39	.77	.44	.37	1.67	—	8.03	
D 45	62.76	.97	22.36	3.07	—	—	—	—	—	6.12	Moisture–2.99
D 46	57.14	1.08	25.52	2.82	—	—	—	—	—	8.12	Moisture–3.48
D 33	67.54	.78	21.54	1.70	—	—	—	—	—	6 29	Moisture–2.48
D 36	68.26	1.14	20.87	2.03	—	—	—	—	—	5.56	Moisture–1.90
D 34	63.20	1.04	22.60	2.50	—	—	—	—	—	7.04	Moisture–3.36
D 35	61.20	1.36	24.11	1.89	—	—	—	—	—	7.20	Moisture–3.88
AK	51.10	.95	34.01	1.41	.37	15	36	.31	—	11.95	
D 10	43.90	2.40	40.79	1.76	—	—	—	—	—	9 90	Moisture–1.25
D 11	48.30	3.20	31.14	1.02	—	—	—	—	—	15.37	Moisture– .97
D 12	56.55	2.75	29.97	1.23	—	—	—	—	—	8.64	Moisture– .86
D 13	47.95	3.01	37.86	1.23	—	—	—	—	—	9.05	Moisture– .90
D 14	52.65	2.92	33.98	0.97	—	—	—	—	—	10.61	Moisture– .87
R 83	48.18	1.20	30.72	1.59	.84	1.02	.01	.29	—	14.11	FeO–.40; P_2O_5–.90
Clay in Devonian Rocks											
D 44	69.92	.98	20.19	1.21	—	—	—	—	—	6.35	Moisture–1.11
Golconda Shale											
Bu 21	60.75	—	20.49	7.30	1.73	.52	—	—	—	6.05	
Bu 22	59.97	—	21.00	7.15	1.58	.60	—	—	—	5.54	
Bu 23	59.90	—	20.27	6.80	1.66	1.14	—	—	—	6.70	
NF 515S	28.94	—	6.67	1.55	1.28	32.87	.08	1.21	25.84	27.93	
NF 535S	27.83	—	9.83	2.95	1.49	30.10	.12	1.41	23.61	26.61	
Kinkaid Shale											
NF 478D	52.60	—	15.45	4.90	1.87	10.51	.12	3.04	7.58	11.79	
NF 478E	57.62	—	16.95	5.09	2.62	4.98	.22	3.71	3.55	8.42	
NF 545A	60.46	—	21.19	5.81	1.80	.63	.25	4.41	.00	5.32	
Loess											
NF 513	71.01	.66	9.94	2.45	2.29	4.02	1.55	2.35	3.70	5.42	FeO–.51; SO_3–.06; V_2O_5–.007
DS 4	63.96	—	13.76	3.27	5.11	5.17	—	—	5.22	8.82	
NF 559	78.63	—	10.94	3.72	.69	.61	.81	1.85	.00	3.21	
NF 264	75.50	—	12.16	4.38	.93	.74	1.12	2.10	.09	3.20	
NF 496	69.25	—	10.16	3.06	2.67	4.32	1.33	2.12	4.94	6.98	
L 10	73.10	—	13.45	5.33	2.18	2.12	—	—	—	2.86	
Menard Shale											
T 2	55.46	—	16.20	5.28	2.82	3.66	—	—	—	—	
T 4	39.20	—	12.11	4.25	3.19	16.82	—	—	—	—	
Moccasin Springs – Bailey Shale											
L 62	61.62	—	19.85	6.56	2.01	.61	.16	3.71	.00	4.97	
NF 528	33.80	.39	7.67	2.05	4.20	24.61	.10	3.53	21.76	23.80	FeO–.57; SO_3–.06; V_2O_5–.007

Table 4.—

Sample number	County	Location T.-R.	sec.	¼	¼	¼	Near	Thickness sampled (ft. in.)	Date*	Remarks
							New Albany Shale			
10	Union	12S-2W	11	—	—	SW	Mountain Glen	10	1921[2]	Along Caney Creek; lower 10′
11	Union	12S-2W	11	—	—	SW	Mountain Glen	25	1921[2]	Along Caney Creek; upper 25′
NF 517	Union	11S-2W	34	SE	NE	NE	Mountain Glen	28	1957[1]	35′ to 68′ above creek
1	Union	12S-2W	23	—	NW	NE	Jonesboro	20	1940[1]	
							Orchard Creek Shale			
NF 523	Alexander	15S-3W	21	SE	SW	NW	Thebes	9	1955[1]	Along Orchard Creek
							Pennsylvanian Shale			
NF 510	Pope	12S-5E	13	Center		E½	Eddyville	21 4	1955[1]	Road cut; sample includes 11″ of interbedded sandstone
							Porters Creek Clay			
La 3	Pulaski	15S-1E	26	SW	NW	NW	Olmsted	15	1948[7]	Lower part of formation
FE 116	Pulaski	15S-1E	27	NE	NE	SE	Olmsted	10	1948[7]	
							Renault Shale			
NF 551S	Johnson	14S-2E	1	NE	NW	SE	Belknap	13	1956[1]	Shale in 32½′ interbedded shale and limestone. See also limestone Sample NF 551L
NF 552S	Massac	14S-3E	3	NE	NW	NW	Forman	13 3	1956[1]	Shale in a 34′ 5″ exposure of interbedded shale and limestone. See also Sample NF 552L
L 11	Union	12S-1W	6	—	—	—	Cobden	10	1912[3]	
L 16	Union	12S-1W	9	SW	NE	SW	Anna	16	1934[4]	
							Residual Clay			
B 21	Hardin	11S-7E	26	S½	SW	SE	Eichorn	7	1948[7]	Residual clay
							Springville Shale			
NF 514 A-1	Union	12S-2W	23	W½	NE	NE	Jonesboro	15	1955[1]	Upper brown shale
NF 514 A-2	Union	12S-2W	23	W½	NE	NE	Jonesboro	10	1955[1]	Lower gray shale
W 286	Union	13S-2W	1	—	NE	SE	Springville	40	1912[3]	
LM 14	Union	13S-2W	26	NE	SE	NE	Mill Creek	10	1948[7]	Along Lingle Creek
NF 413	Union	13S-2W	26	NW	NW	NE	Mill Creek	7	1948[7]	Along tributary to Lingle Creek. Calico shale.
NF 541	Union	13S-2W	26	SE	SW	NE	Jonesboro	29	1955[1]	Bluff along creek
							Tar Springs Shale			
NF 554S	Johnson	13S-3E	17	NE	NE	NE	Vienna	6	1956[1]	Overlies NF 554L
							Vienna Shale			
NF 520	Johnson	13S-4E	12	SW	SW	NE	Grantsburg	37 6	1955[1]	Railroad cut
							Clay of Uncertain Age			
D 56	Pope	12S-6E	16	—	—	—	Raum	—	1907[6]	Halloysite clay

*Date when sample was taken; if sampling date is not known, the date given is that of the publication of the analysis.

[1]Analysis made by L. D. McVicker in laboratories of Illinois State Geological Survey.

[2]Parr, S. W., and Austin, M. M., 1921, Potash shales of Illinois: Univ. of Ill. Agr. Exp. Station Bull. 232, p. 236; Krey, Frank, 1920, Geology, distribution, and occurrence of the potash shales of Union Co.: Illinois Geol. Survey unpublished manuscript. Analyses recalculated.

[3]Bleininger, A. V., Lines, E. F., and Layman, F. E., 1922, Portland cement resources of Illinois: Illinois Geol. Survey Bull. 17, p. 104, 111 and 113.

(Continued)

Sample number	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	CO_2	Ignition loss	Other components
New Albany Shale											
10	53.7	—	16.3	5.7	1.6	0.8	0.5	5.0	—	12.7	
11	56.4	—	15.2	5.6	1.1	0.2	0.6	4.3	—	14.5	
NF 517	62.71	.74	13.16	4.44	1.39	.18	.15	4.39	.00	12.32	SO_3–.84; V_2O_5–.071
1	56.88	.75	13.85	5.72	1.83	.70	.57	4.19	—	15.90	
Orchard Creek Shale											
NF 523	34.70	—	8.14	2.52	1.50	27.34	.08	2.76	21.44	23.39	
Pennsylvanian Shale											
NF 510	65.26	.86	18.21	4.97	1.06	.35	.13	3.32	.00	5.58	FeO–.41; SO_3–.05; V_2O_5–.021
Porters Creek Clay											
La 3	69.07	.84	11.87	4.36	1.79	.85	.00	1.40	.03	10.21	S–0.0
FE 116	61.06	.21	15.99	4.50	2.00	.86	.07	1.43	—	13.36	FeO–.12; P_2O_5–.36
Renault Shale											
NF 551S	46.74	—	10.61	3.49	2.52	16.81	.46	2.07	13.92	17.14	
NF 552S	33.99	—	10.30	3.72	2.09	24.60	.10	2.87	19.53	22.92	
L 11	64.78	—	18.17	6.74	1.69	1.43	—	—	—	5.62	
L 16	46.54	—	17.85	—	2.01	14.06	—	—	—	—	
Residual Clay											
B 21	56.96	.37	23.47	8.84	.82	.53	.30	1.56	—	7.92	
Springville Shale											
NF 514 A-1	81.47	—	10.00	2.78	1.05	.19	.15	2.38	.00	2.69	
NF 514 A-2	74.71	—	11.97	3.36	1.46	1.34	.16	3.37	1.03	4.10	
W 286	71.24	—	13.74		1.50	5.32	—	—	—	7.66	
LM 14	78.63	.60	11.36	2.33	.79	.10	.11	2.68	.04	3.38	
NF 413	77.88	.66	12.85	1.61	.97	.33	.17	2.60	—	3.44	MnO–.008
NF 541	73.38	.59	12.93	2.64	1.78	.40	.19	3.68	.11	3.56	FeO–1.16; SO_3–.07; V_2O_5–.036
Tar Springs Shale											
NF 554S	58.70	—	23.28	4.80	1.61	.47	.21	3.83	.00	7.95	
Vienna Shale											
NF 520	60.42	—	15.76	10.50	1.66	2.47	.20	2.11	1.58	7.28	
Clay of Uncertain Age											
D 56	58.06	.14	26.57	1.23	—	—	—	—	—	9.84	Moisture–4.62

[4] Lamar, J. E., Willman, H. B., Fryling, C. F., and Voskuil, W. H., 1934, Rock wool from Illinois mineral resources: Illinois Geol. Survey Bull. 61, p. 150.

[5] Piersol, R. J., Lamar, J. E., and Voskuil, W. H., 1933, Anna kaolin as a new decolorizing agent for vegetable oils: Illinois Geol. Survey Rept. Inv. 27, p. 25.

[6] Purdy, R. C., and DeWolf, F. W., 1907, Preliminary investigation of Illinois fireclays: Illinois Geol. Survey Bull. 4, Yearbook for 1906, p. 149-153, 155-159, 173, and 175.

[7] Lamar, J. E., 1948, Clay and shale resources of extreme Southern Illinois: Illinois Geol. Survey Rept. Inv. 128, p. 18, 19.

[8] Analysis by Chemistry Dept., University of Illinois.

TABLE 5.—CHEMICAL ANALYSES OF SOUTHERN ILLINOIS

Sample number	Formation	Location					Near	Thickness (ft. in.)	Date†	Remarks
		T.-R.	sec.	¼	¼	¼				
							ALEXANDER COUNTY			
							Limestone			
NF 530	Bailey	15S-2W	19	SW	NW	SW	Olive Branch	11 4	1955[1]	Limestone portion of an outcrop which contains 6′ 1″ of chert and shale
NF 534	Burlington-Keokuk	14S-1W	22	NW	SE	NW	Ullin	22 6	1955[1]	About 10% of chert in deposit not included in sample
NF 512	Girardeau	15S-3W	21	SW	SE	NW	Thebes	19 6	1955[1]	Outcrop at Rock Springs
L 37	Girardeau	15S-3W	21	SW	SE	NW	Thebes	25	1928[5]	At Rock Springs
NF 522A	Kimmswick	15S-3W	17	SE	NW	SE	Thebes	13 6	1955[1]	Railroad cut
NF 522B	Kimmswick	15S-3W	20	NW	NE	NE	Thebes	14 6	1955[1]	Bank of Mississippi River
L 57	Kimmswick	15S-3W	17	—	—	SE	Thebes	22	1928[2]	
L 58	Kimmswick	15S-3W	17	—	—	SE	Thebes	28	1928[2]	
L 63A	Kimmswick	15S-3W	17	—	—	SE	Thebes	20	1928[2]	
NF 450	Kimmswick	15S-3W	17	SE	NW	SE	Thebes	26	1949[2]	
NF 524	Moccasin Springs	15S-3W	22	SE	SE	SW	Thebes	15	1955[1]	In creek bed
NF 525L	Sexton Creek	14S-3W	27	SE	SW	SW	Gale	36	1955[1]	Deposit cherty; chert not included in this sample
NF 449	St. Clair	14S-3W	12	SW	SE	NW	McClure	23 6	1949[3]	Basal 24½′ of formation
							Clay and Shale			
NF 570	Alluvium	14S-3W	12	NW	SE	NW	McClure	7	1957[1]	
NF 513	Loess	14S-3W	33	NE	NE	SW	Gale	25 6	1955[1]	Upper 6′ and lower 19½′ of loess exposed in borrow pit
DS 4	Loess	15S-3W	4	NW	SE	NW	Gale	48	1948[11]	Road cut
NF 528	Moccasin Springs	14S-3W	23	SW	NW	SW	McClure	25	1957[1]	Contains limestone nodules
L 62	Moccasin Springs	15S-3W	21	E½	SW	SE	Thebes	20	1957[1]	Along Orchard Creek
NF 523	Orchard Creek	15S-3W	21	SE	SW	NW	Thebes	9	1955[1]	Along Orchard Creek
							HARDIN COUNTY			
							Limestone			
NF 555A	Renault	12S-7E	35	SW	NE	SW	Shetlerville	8 5	1956[1]	Old quarry; lower Renault limestone
NF 176C	Renault	12S-7E	35	—	E½	SW	Shetlerville	12 7	1934[2]	39′ 11″ to 52′ 6″; lower Renault limestone
NF 176D	Renault	12S-7E	35	—	E½	SW	Shetlerville	5 4	1934[2]	52′ 6″ to 57′ 10″; lower Renault limestone
NF 177A	Ste. Genevieve (Fredonia M.)	12S-7E	35	S½	N½	SE	Shetlerville	16 6	1934[2]	P. R. Brown Stone Co.; 0 to 16′ 6″ above base
NF 177B	Ste. Genevieve (Fredonia M.)	12S-7E	35	S½	N½	SE	Shetlerville	22 1	1934[5]	P. R. Brown Stone Co.; 16′ 6″ to 38′ 7″ above base
NF 177C	Ste. Genevieve (Fredonia M.)	12S-7E	35	S½	N½	SE	Shetlerville	32 5	1934[5]	P. R. Brown Stone Co.; 38′ 7″ to 72′ 10″
NF 177D	Ste. Genevieve (Fredonia M.)	12S-7E	35	S½	N½	SE	Shetlerville	11 4	1934[2]	P. R. Brown Stone Co.; 72′ 10″ to 84′ 2″
Kx	Ste. Genevieve (Fredonia M.**)	12S-7E	35	—	—	—	Shetlerville	— —	1925[4]	Outcrops in Rich Hill
NF 548A	Ste. Genevieve (Fredonia M.)	12S-8E	14	Center		SE	Elizabethtown	23	1956[1]	Road cut along Route 146
NF 548B	Ste. Genevieve (Fredonia M.)	12S-8E	14	—	NE	SE	Elizabethtown	11 6	1956[1]	Road cut along Route 146

Limestones and Clays and Shales Arranged by County

Sample number	$CaCO_3$	$MgCO_3$	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	R_2O_3	Na_2O	K_2O	CO_2	Ignition loss	Other components
ALEXANDER COUNTY													
Limestone													
NF 530	47.95*	3.72*	26.87	1.78	42.80	3.38	1.19	—	.06	.79	21.38	23.18	
NF 534	78.06*	5.98*	43.74	2.86	15.19	.74	.22	—	.03	.08	36.82	37.16	
NF 512	80.70*	6.80*	45.22	3.25	9.41	1.85	.64	—	.03	.45	38.30	38.89	MnO–.056; P_2O_5–.065; SO_3–.29; SrO–.048
L 37	90.86	4.80	50.82*	2.20*	3.72	1.40		—	—	—	—	—	
NF 522A	99.60	.61	55.81	.29	.15	.20	.09	—	.01	.01	43.67	43.61	MnO–.036; P_2O_5–.087; SO_3–.02; SrO–.018
NF 522B	99.53	.84	55.77	.40	.14	.20	.09	—	.01	.01	43.73	43.57	MnO–.048; P_2O_5–.094; SO_3–.05; SrO–.015
L 57	97.44	0.38	54.61	.18	.20	.10	.25	—	—	—	—	—	
L 58	96.90	0.60	54.30	.29	.90	.36	.10	—	—	—	—	—	
L 63A	98.54	0.55	55.22	.26	.32	.32	.10	—	—	—	—	—	
NF 450	99.69	.71	55.86	.34	.16	.20	.09	—	.06	.01	43.53	43.44	MnO–.038; P_2O_5–.034; TiO_2–nil
NF 524	69.62*	2.91*	39.01	1.39	19.42	5.15	1.39	—	.05	1.64	30.59	32.00	
NF 525L	94.71	2.01	53.07	.96	3.59	.78	.26	—	.02	.17	41.89	41.90	
NF 449	95.00*	1.44*	53.23	.69	2.82	.90	.35	—	.04	.22	41.95	41.99	TiO_2–.13; MnO–.044; P_2O_5–.005
Clay and Shale													
NF 570	—	—	1.25	1.14	72.79	13.45	3.79	—	.90	2.11	.13	4.04	
NF 513	—	—	4.02	2.29	71.01	9.94	2.45	—	1.55	2.35	3.70	5.42	TiO_2–.66; FeO–.51; SO_3–.06; V_2O_5–.007
DS 4	—	—	5.17	5.11	63.96	13.76	3.27	—	—	—	5.22	8.82	
NF 528	—	—	24.61	4.20	33.80	7.67	2.05	—	.10	3.53	21.76	23.80	TiO_2–.39; FeO–.57; SO_3–.06; V_2O_5–.007
L 62	—	—	.61	2.01	61.62	19.85	6.56	—	.16	3.71	.00	4.97	
NF 523	—	—	27.34	1.50	34.70	8.14	2.52	—	.08	2.76	21.44	23.39	
HARDIN COUNTY													
Limestone													
NF 555A	83.72	1.88	46.91	.90	12.33	1.31	.46	—	.04	.26	37.45	37.78	
NF 176C	81.68	2.94	45.77	1.41	13.17	2.16	.72	—	—	—	36.51	36.80	
NF 176D	94.99	2.99	53.23	1.43	1.95	.11	.81	—	—	—	42.53	42.47	
NF 177A	98.28	1.08	55.07	.52	1.13	.51	.31	—	—	—	42.57	43.15	P_2O_5–.020; MnO–0.02; SO_3–.07
NF 177B	99.58*	.23*	55.80	.11	.59	.32	.26	—	—	—	43.47	43.42	P_2O_5–.009; MnO–.008; SO_3–.15
NF 177C	88.80*	5.10*	49.76	2.44	4.84	1.59	1.04	—	—	—	41.25	41.03	
NF 177D	95.49*	3.28*	53.51	1.57	1.73	.54	.56	—	—	—	42.93	42.81	
Kx	83.20	8.31	46.63*	3.97*	5.54	—	—	2.41	—	—	—	—	
NF 548A	85.86*	9.89*	48.11	4.73	4.03	.39	.26	—	.03	.06	42.42	42.54	
NF 548B	91.53*	2.03*	51.29	.97	6.70	.50	.12	—	.03	.05	40.66	40.76	

TABLE 5.—

Sample number	Formation	Location T.-R.	sec.	¼	¼	¼	Near	Thickness (ft. in.)	Date†	Remarks
							HARDIN COUNTY			
							Limestone—continued			
NF 548C	Ste. Genevieve (Fredonia M.)	12S-8E	14	NEc	NE	SE	Elizabethtown	40 3	1956[1]	Road cut along Route 146
W 322	Ste. Genevieve (Fredonia M.**)	12S-8E	27	—	—	SW	Elizabethtown	50	1912[3]	
NF 511A	Ste. Genevieve (Fredonia M.)	12S-8E	27	NE	SW	SW	Elizabethtown	28 6	1955[1]	J. L. Bean Stone Co.; 6′ to 34½′ below top of quarry
NF 511B	Ste. Genevieve (Fredonia M.)	12S-8E	27	NE	SW	SW	Elizabethtown	17	1955[1]	J. L. Bean Stone Co.; 34½′ to 51½′
NF 511C	Ste. Genevieve (Fredonia M.)	12S-8E	27	NE	SW	SW	Elizabethtown	22 6	1955[1]	J. L. Bean Stone Co.; 51½′ to 74′
NF 454A	Ste. Genevieve (Fredonia M.)	12S-9E	12	NE	NW	NW	Cave in Rock	38 4	1951[2]	Okerson quarry; 1′ 8″ to 40′ above base
NF 454B	Ste. Genevieve (Fredonia M.)	12S-9E	12	NE	NW	NW	Cave in Rock	12 4	1951[2]	Okerson quarry; 43′ 9″ to 56′ 1″
NF 454C	Ste. Genevieve (Fredonia M.)	12S-9E	12	NE	NW	NW	Cave in Rock	13 4	1951[2]	Okerson quarry; 56′ 1″ to 69′ 5″
NF 454D	Ste. Genevieve (Fredonia M.)	12S-9E	12	NE	NW	NW	Cave in Rock	15 2	1951[2]	Okerson quarry; 72′ 5″ to 87′ 7″
NF 453A	Ste. Genevieve (Fredonia M.)	12S-9E	12	NE	NE	NW	Cave in Rock	9 7	1951[2]	Rigsby & Barnard quarry; 0 to 9′ 7″ above base
NF 453B	Ste. Genevieve (Fredonia M.)	12S-9E	12	NE	NE	NW	Cave in Rock	14 5	1951[2]	Rigsby & Barnard quarry; 9′ 7″ to 24′ 0″
NF 453C	Ste. Genevieve (Fredonia M.)	12S-9E	12	NE	NE	NW	Cave in Rock	10 7	1951[2]	Rigsby & Barnard quarry; 24′ to 34′ 7″
NF 453D	Ste. Genevieve (Fredonia M.)	12S-9E	12	NE	NE	NW	Cave in Rock	12 7	1951[2]	Rigsby & Barnard quarry; 36′ 11″ to 49′ 6″
NF 453E	Ste. Genevieve (Fredonia M.)	12S-9E	12	NE	NE	NW	Cave in Rock	14 5	1951[2]	Rigsby & Barnard quarry; 49′ 6″ to 63′ 11″
NF 453F	Ste. Genevieve (Fredonia M.)	12S-9E	12	NE	NE	NW	Cave in Rock	16 7	1951[2]	Rigsby & Barnard quarry; 63′ 11″ to 80′ 6″ above base
W 330	Ste. Genevieve (Fredonia M.**)	13S-8E	5	—	—	SW	Rosiclare	37	1912[3]	
NF 176A	Ste. Genevieve (Levias M.)	12S-7E	35	—	E½	SW	Shetlerville	10 7	1934[2]	12′ 4″ to 22′ 11″ above base of exposure
NF 176B	Ste. Genevieve (Levias M.)	12S-7E	35	—	E½	SW	Shetlerville	17	1934[2]	22′ 11″ to 39′ 11″ above base of exposure
NF 555CD	Ste. Genevieve (Levias M.)	12S-7E	35	SW	NE	SW	Shetlerville	8 6	1956[1]	Lower part of old quarry
NF 508A	St. Louis	12S-9E	23	—	NE	NW	Cave in Rock	22 6	1954[1]	Abandoned quarry; upper two benches
NF 508B	St. Louis	12S-9E	23	—	NE	NW	Cave in Rock	22 8	1954[1]	Abandoned quarry; two middle benches
NF 508C	St. Louis	12S-9E	23	—	NE	NW	Cave in Rock	13 4	1954[1]	Abandoned quarry; lower bench
NF 546	Warsaw-Salem	11S-7E	25	—	SW	SW	Hicks	32	1956[1]	32′ of limestone in a 63-foot section, 31′ covered

(Continued)

Sample number	$CaCO_3$	$MgCO_3$	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	R_2O_3	Na_2O	K_2O	CO_2	Ignition loss	Other components
HARDIN COUNTY													
Limestone—continued													
NF 548C	76.10*	13.38*	42.64	6 40	9.09	.96	.43	—	.03	.16	40.17	40 26	
W 322	80.43	7.56	45.08	3.62	9.10	2.14		—	—	—	—	40.18	
NF 511A	70 85*	16.40*	39.70	7.84	10.76	1.16	.62	—	.04	.24	38.78	39.58	MnO-.014; P_2O_5-.076; SO_3-.20; SrO-.061
NF 511B	89.55*	4.41*	50.18	2.11	5.37	.72	.18	—	.03	.09	40.66	41.39	MnO-.007; P_2O_5-.066; SO_3-.12; SrO-.082
NF 511C	93.28*	2.55*	52.27	1.22	3.60	.44	.21	—	.03	.07	42.09	42.11	MnO-.006; P_2O_5-.064; SO_3-.12; SrO-.078
NF 454A	91.39*	5.90*	51.21	2.82	2.12	.54	.31	—	.14	.06	42.85	43.07	P_2O_5-.035
NF 454B	92.98*	2.40*	52.10	1.15	3.91	.65	.26	—	.14	.11	41.76	42.02	P_2O_5-.043
NF 454C	81.79*	4 83*	45 83	2.31	10.41	1.89	.75	—	.19	.42	37.97	38 61	P_2O_5-.067
NF 454D	92.39*	3 68*	51.77	1.76	2.89	.88	.42	—	.18	.20	42.10	42.45	P_2O_5-.038
NF 453A	90 57*	7.09*	50.75	3.39	1.34	1.00	.27	—	.08	.06	43.09	43.34	P_2O_5-.023
NF 453B	98.47*	1.13*	55.18	.54	.03	.63	.13	—	.07	.03	43.51	43.74	P_2O_5-.010
NF 453C	95 73*	1.46*	53 64	.70	1.73	.97	.31	—	.10	.11	42.57	42.68	P_2O_5-.017
NF 453D	92.37*	2.36*	51.76	1.13	3.86	1.11	.29	—	.11	.13	41.45	41 78	P_2O_5-.031
NF 453E	82 23*	5 58*	46 08	2.67	8.86	2.17	.67	—	.24	.36	38.57	39 12	P_2O_5-.053
NF 453F	96.07*	1 99*	53.83	.95	1.77	.51	.25	—	.20	.06	42.75	43 08	P_2O_5-.029
W 330	85.82	2.21	48 10	1.06	7.78	4.10		—	—	—	—	39 72	
NF 176A	50 54*	3 93*	28.32	1 88	39.07	6.28	1.54	—	—	—	22.48	22 76	
NF 176B	94.10*	3.12*	52 73	1.49	2.43	.25	.78	—	—	—	42.31	42.30	
NF 555CD	92 07*	1 82*	51 59	0 87	4 59	1.38	.53	—	.08	15	44 15	41 39	
NF 508A	71.81	14.55	40.24	6.96	13.04	.66	.21	—	.03	.08	38.64	38.82	
NF 508B	84 29	5.02	47.23	2 40	10.38	.63	.16	—	.04	.09	39.07	39.23	
NF 508C	81 39	14.39	45.61	6 88	3.75	.76	.26	—	.03	.12	42.47	42 87	
NF 546	55.70	3.20	31.21	1.53	37.93	1.82	.42	—	.15	.34	25.55	26.66	

Table 5.—

Sample number	Formation	T.-R.	sec.	¼	¼	¼	Near	Thickness (ft. in.)	Date†	Remarks
HARDIN COUNTY										
Clay and Shale										
NF 559	Loess	12S–8E	30	SE	SE	NW	Rosiclare	10	1956[1]	Road cut
B 21	Residual Clay	11S–7E	26	S½	SW	SE	Eichorn	7	1948[11]	Residual clay
JACKSON COUNTY										
Limestone										
NF 536 (10–38)	Backbone	10S–3W	27	—	W½	SW	Howardton	29	1955[1]	Mississippi River bluff south of Rattlesnake Ferry
JOHNSON COUNTY										
Limestone										
NF 554L	Glen Dean	13S–3E	17	NE	NE	NE	Vienna	20	1956[1]	Abandoned quarry. Overlain by NF 554S, Tar Springs shale
W 308	Golconda	13S–3E	16	—	cen.	W½	Vienna	30	1912[3]	May have interbedded shale
NF 478A	Kinkaid	12S–2E	15	NE	SW	NE	Buncombe	18 4	1955[1]	Southern Illinois Stone Co.; 0′ to 18′ 4″ above base of quarry
NF 478B	Kinkaid	12S–2E	15	NE	SW	NE	Buncombe	21	1955[1]	Southern Illinois Stone Co.; 18′ 4″ to 39′ 4″ above base of quarry
NF 478C	Kinkaid	12S–2E	15	NE	SW	NE	Buncombe	19 1	1955[1]	Southern Illinois Stone Co.; 39′ 4″ to 53′ 5″ above base of quarry
K 29	Kinkaid	12S–3E	16	—	—	—	Bloomfield	—	1925[4]	
Wills 1–6	Kinkaid	12S–4E	23	E½	SW	NE	Simpson	9	1950[2]	Abandoned quarry
NF 556A	Kinkaid	12S–4E	23	N½	SW	NE	Simpson	10 4	1956[1]	Limestone in 12′ 7″ of stone; old Wills quarry
NF 556B	Kinkaid	12S–4E	23	N½	SW	NE	Simpson	2 3	1956[1]	Limestone and shale interbedded with NF 556A
NF 556C	Kinkaid	12S–4E	23	N½	SW	NE	Simpson	17	1956[1]	Limestone below NF 556A and B
NF 558A	Menard	12S–2E	27	SE	NW	SE	West Vienna	16 11	1956[1]	Limestone in 26′ of stone
NF 558C	Menard	12S–2E	27	SE	NW	SE	West Vienna	9 1	1956[1]	Shale and interlayered limestone interbedded with NF 558A
T 1	Menard	13S–4E	1	—	NE	SW	Flatwoods	7	1926[5]	South portal Flatwoods tunnel; 0′ to 7′ above base of cut
T 3	Menard	13S–4E	1	—	NE	SW	Flatwoods	33	1926[6]	South portal Flatwoods tunnel; interbedded limestone and shale 11′ to 44′ above base
T 5	Menard	13S–4E	1	—	NE	SW	Flatwoods	34	1926[5]	South portal Flatwoods tunnel; limestone in 40′ of interbedded limestone and shale; 44′ to 84′ above base
NF 551L	Renault	14S–2E	1	NE	NW	SE	Belknap	19 6	1956[1]	Belknap quarry, ¼ mile NE Belknap; 19½′ limestone in 32½′ interbedded limestone and shale; see also shale
NF 560	Renault	13S–3E	32	SE	SE	SW	Indian Point	13 5	1956[1]	Railroad cut
D 16	Ste. Genevieve (Fredonia M.**)	14S–2E	1	—	—	—	Belknap	18	1912[3]	
D 17	Ste. Genevieve (Fredonia M.)	14S–2E	1	—	—	—	Belknap	15	1912[3]	
NF 175A	Ste. Genevieve (Fredonia M.)	14S–2E	5	—	SW	SW	Whitehill	10 2	1934[2]	Charles Stone Co.; 0′ to 10′ 2″ above base
NF 175B	Ste. Genevieve (Fredonia M.)	14S–2E	5	—	SW	SW	Whitehill	24 5	1934[2]	Charles Stone Co.; 10′ 2″ to 34′ 7″
NF 175C	Ste. Genevieve (Fredonia M.)	14S–2E	5	—	SW	SW	Whitehill	11 2	1934[2]	Charles Stone Co.; 34′ 7″ to 45′ 9″
NF 175D	Ste. Genevieve (Fredonia M.)	14S–2E	5	—	SW	SW	Whitehill	56 4	1934[2]	Charles Stone Co.; 45′ 9″ to 102′ 1″
NF 175E	Ste. Genevieve (Fredonia M.)	14S–2E	5	—	SW	SW	Whitehill	25 5	1934[2]	Charles Stone Co.; 102′ 1″ to 127′ 6″
W 304	Ste. Genevieve (Fredonia M.**)	14S–2E	5	—	—	—	Whitehill	60	1912[3]	
NF 521	Vienna	13S–4E	12	SW	SW	NE	Grantsburg	20 4	1955[1]	Chert in deposit not included in sample
L 100	Vienna	13S–4E	12	—	—	E½	Grantsburg	20	1928[5]	

(Continued)

Sample number	$CaCO_3$	$MgCO_3$	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	R_2O_3	Na_2O	K_2O	CO_2	Ignition loss	Other components
						HARDIN COUNTY							
						Clay and Shale							
NF 559	—	—	.61	.69	78.63	10.94	3.72	—	.81	1.85	.00	3.21	
B 21	—	—	.53	.82	56.96	23.47	8.84	—	.30	1.56	—	7.92	TiO_2–.37
						JACKSON COUNTY							
						Limestone							
NF 536 (10–38)	95.37*	3.62*	53.44	1.73	.98	.37	.19	—	.02	.03	43.56	43.46	SrO–.014
						JOHNSON COUNTY							
						Limestone							
NF 554L	91.39*	1.84*	51.21	.88	4.13	1.06	1.19	—	.03	.10	40.85	41.31	
W 308	95.57	1.55	53.56	0.74	.96	1.76		—	—	—	—	—	
NF 478A	69.62	9.35	39.01	4.47	14.68	3.07	1.27	—	.12	.60	34.39	35.76	MnO–.016; P_2O_5–.081; SO_3–1.28; SrO–.050
NF 478B	65.08	11.52	36.47	5.51	20.01	1.23	.76	—	.09	.20	34.18	34.70	MnO–.012; P_2O_5–.023; SO_3–.78; SrO–.044
NF 478C	69.15	4.77	38.75	2.88	17.65	4.31	1.29	—	.09	.99	32.32	33.48	MnO–.030; P_2O_5–.084; SO_3–.70; SrO–.051
K 29	91.45	3.10	51.25	1.48	4.74	.74		—	—	—	—	—	
Wills 1–6	87.21	3.76	48.87	1.80	6.56	1.44	.73	—	.11	.24	39.64	39.90	TiO_2–.10; MnO–.032; P_2O_5–.030
NF 556A	90.16	2.64	50.52	1.26	5.36	1.23	.95	—	.03	.10	40.55	41.02	
NF 556B	60.09	12.80	33.67	6.12	18.29	5.13	2.01	—	.17	.80	32.39	34.09	
NF 556C	89.39	3.49	50.09	1.67	5.52	1.40	.64	—	.06	.17	40.69	40.92	
NF 558A	87.02	2.11	48.77	1.01	8.36	1.55	.66	—	.06	.16	38.85	39.30	
NF 558C	78.08	2.01	43.75	.96	12.82	3.83	2.17	—	.04	.43	34.40	36.27	
T 1	87.29*	3.74*	48.90	1.53	5.50	3.19	1.53	—	—	—	—	—	
T 3	58.43*	8.34*	32.74	3.99	20.90	7.12	3.32	—	—	—	—	—	
T 5	77.50*	5.71*	43.42	2.73	12.30	1.53	1.79	—	—	—	—	—	
NF 551L	88.55	3.43	49.62	1.64	6.47	1.31	.52	—	.12	.13	39.96	40.36	
NF 560	93.05	2.13	52.14	1.02	3.53	1.04	.79	—	.30	.08	41.29	41.69	
D 16	90.17	3.65	50.53*	1.75	6.00	1.32		—	—	—	—	—	
D 17	93.11	2.01	52.18*	.96	5.38	.83		—	—	—	—	—	
NF 175A	82.40	13.78	46.17	6.59	3.18	.81	.46	—	—	—	42.99	42.71	
NF 175B	94.39	1.53	52.89	.73	3.51	.57	.35	—	—	—	42.43	42.00	
NF 175C	64.82	21.21	36.32	10.14	13.78	2.03	.66	—	—	—	37.06	37.67	
NF 175D	97.10	2.42	54.41	1.16	1.44	.37	.28	—	—	—	43.42	43.09	SO_3–.22
NF 175E	88.84	3.74	49.78	1.79	6.81	1.46	.64	—	—	—	39.24	40.19	
W 304	94.07	3.14	52.72	1.50	2.04	1.22		—	—	—	—	—	
NF 521	74.86	7.99	41.95	3.82	14.10	1.48	1.98	—	.06	.16	36.75	36.97	
L 100	75.52	7.49	42.29	3.58	13.02	0.57	1.33	—	—	—	—	—	

TABLE 5.—

Sample number	Formation	Location T.-R.	sec.	¼	¼	¼	Near	Thickness (ft.	in.)	Date†	Remarks
JOHNSON COUNTY											
Clay and Shale											
NF 478D	Kinkaid	12S-2E	15	NE	SW	NE	Buncombe	7		1952[1]	Overburden Southern Illinois Stone Co.
NF 478E	Kinkaid	12S-2E	15	NE	SW	NE	Buncombe	5	9	1952[1]	Southern Illinois Stone Co. overburden
T 2	Menard	13S-4E	1	—	NE	SW	Flatwoods	4		1926[7]	7′ to 11′ above base of cut, south portal of tunnel
T 4	Menard	13S-4E	1	—	NE	SW	Flatwoods	6		1926[6]	44′ to 84′ above base of cut, south portal of tunnel; shale in 40′ interbedded limestone and shale
NF 551S	Renault	14S-2E	1	NE	NW	SE	Belknap	13		1956[1]	Shale in 32½′ interbedded shale and limestone. See also limestone Sample NF 551L
NF 554S	Tar Springs	13S-3E	17	NE	NE	NE	Vienna	6		1956[1]	Overlies NF 554L
NF 520	Vienna	13S-4E	12	SW	SW	NE	Grantsburg	37	6	1955[1]	Railroad cut
MASSAC COUNTY											
Limestone											
NF 552L	Renault	14S-3E	3	NE	NW	NW	Forman	21	2	1956[1]	21′ 2″ limestone in an exposure of 34′ 5″ of limestone and shale in an old quarry
Clay and Shale											
NF 469	Alluvium	15S-4E	27	NE	NW	SW	Choat	8		1952[1]	
D 32	Cretaceous	14S-5E	33	—	—	SE	Round Knob	4		1907[10]	
D 28	Cretaceous	15S-4E	1	—	—	SW	Round Knob	6		1907[10]	
D 29	Cretaceous	15S-4E	2	—	N½	SW	Round Knob	—		1907[10]	
D 30	Cretaceous	15S-4E	2	—	N½	SW	Round Knob	6		1907[10]	
D 31	Cretaceous	15S-4E	2	—	N½	SW	Round Knob	7	6	1907[10]	
D 50	Cretaceous	16S-6E	12	—	—	—	Unionville	2		1907[10]	
NF 552S	Renault	14S-3E	3	NE	NW	NW	Forman	13	3	1956[1]	Shale in a 34′ 5″ exposure of interbedded shale and limestone. See also Sample NF 552L
POPE COUNTY											
Limestone											
Bu 20	Golconda	13S-6E	26	—	—	SE	Golconda	50		1912[3]	Limestone in an outcropping of 100′ or more of limestone and shale
W 319	Golconda	13S-7E	19	—	—	—	Golconda	15		1912[3]	Bluff just north of Golconda
DS 24	Kinkaid	12S-5E	19	—	NW	SE	Robbs	5		1934[7]	Associated with shale. Railroad cut
NF 550	Kinkaid	13S-5E	14	SW	SW	NE	Dixon Springs	29		1956[1]	Pine Hollow quarry
D 48	Menard	13S-5E	31	—	—	SW	Reevesville	32		1912[3]	Location corrected
W 311	Menard	13S-5E	31	—	—	SW	Reevesville	50		1912[3]	Location corrected. Deposit has shale partings
W 320	Ste. Genevieve	11S-7E	22	—	SW	SE	Hicks	15		1912[3]	Limestone has shale partings
Clay and Shale											
D 34	Cretaceous	14S-5E	26	—	—	—	Rosebud	3		1907[10]	
D 35	Cretaceous	14S-5E	26	—	—	—	Rosebud	2		1907[10]	
Bu 21	Golconda	13S-6E	26	—	—	—	Golconda	5	6	1912[3]	
Bu 22	Golconda	13S-6E	26	—	—	—	Golconda	5	6	1912[3]	
Bu 23	Golconda	13S-6E	26	—	—	—	Golconda	6	6	1912[3]	
NF 264	"Loess"	13S-6E	24	SE	SW	NE	Golconda	20		1957[1]	Road cut
NF 510	Pennsylvanian	12S-5E	13	cen.	—	E½	Eddyville	21	4	1955[1]	Road cut; sample includes 11″ of interbedded sandstone
D 56	Uncertain	12S-6E	16	—	—	—	Raum	—		1907[10]	Halloysite clay
PULASKI COUNTY											
Limestone											
NF 451D	Warsaw-Salem	14S-1W	14	SE	SW	NE	Ullin	21		1949[1]	Columbia Quarry Co.; 80′ to 101′ above quarry floor
NF 451A	Warsaw-Salem	14S-1W	14	SE	SW	NE	Ullin	14		1949[2]	Columbia Quarry Co.; 66′ to 80′ above quarry floor
NF 451B	Warsaw-Salem	14S-1W	14	SE	SW	NE	Ullin	25		1949[2]	Columbia Quarry Co.; 41′ to 66′ above quarry floor
NF 451C	Warsaw-Salem	14S-1W	14	SE	SW	NE	Ullin	41		1949[1]	Columbia Quarry Co.; 0′ to 41′ above quarry floor
NF 451E	Warsaw-Salem	14S-1W	14	SE	SW	NE	Ullin	35	8	1951[1]	Columbia Quarry Co.; 0′ to 36′ below quarry floor mentioned above
D 47	Warsaw-Salem	14S-1W	14	—	—	—	Ullin	40		1912[3]	Lower 40′ in old quarry
L 10	Warsaw-Salem	14S-1W	14	—	SW	NE	Ullin	40		1928[5]	

(Continued)

Sample number	$CaCO_3$	$MgCO_3$	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	R_2O_3	Na_2O	K_2O	CO_2	Ignition loss	Other components
JOHNSON COUNTY													
Clay and Shale													
NF 478D	—	—	10.51	1.87	52.60	15.45	4.90	—	.12	3.04	7.58	11.79	
NF 478E	—	—	4.98	2.62	57.62	16.95	5.09	—	.22	3.71	3.55	8.42	
T 2	—	—	3.66	2.82	55.46	16.20	5.28	—	—	—	—	—	
T 4	—	—	16.82	3.19	39.20	12.11	4.25	—	—	—	—	—	
NF 551S	—	—	16.81	2.52	46.74	10.61	3.49	—	.46	2.07	13.92	17.14	
NF 554S	—	—	.47	1.61	58.70	23.28	4.80	—	.21	3.83	.00	7.95	
NF 520	—	—	2.47	1.66	60.42	15.76	10.50	—	.20	2.11	1.58	7.28	
MASSAC COUNTY													
Limestone													
NF 552L	91.16	1.92	51.08	.92	5.23	1.06	.46	—	.04	.15	40.54	41.06	
Clay and Shale													
NF 469	—	—	.47	.35	83.76	9.53	1.92	—	.46	.65	.05	2.62	
D 32	—	—	—	—	64.88	21.54	1.86	—	—	—	—	6.83	TiO_2–1.26; Moisture–2.58
D 28	—	—	—	—	66.04	22.00	1.60	—	—	—	—	6.81	TiO_2–1.60; Moisture–1.64
D 29	—	—	—	—	71.58	18.31	1.51	—	—	—	—	5.27	TiO_2–1.40; Moisture–1.41
D 30	—	—	—	—	60.50	22.52	3.84	—	—	—	—	7.52	TiO_2–1.40; Moisture–3.44
D 31	—	—	—	—	69.46	18.82	1.32	—	—	—	—	5.31	TiO_2–1.64; Moisture–1.13
D 50	—	—	—	—	63.32	19.25	4.09	—	—	—	—	6.02	TiO_2–.48; Moisture–3.55
NF 552S	—	—	24.60	2.09	33.99	10.30	3.72	—	.10	2.87	19.53	22.92	
POPE COUNTY													
Limestone													
Bu 20	88.75*	1.94*	49.74	.93	7.66	2.02		—	—	—	—	39.85	
W 319	86.43	3.34	48.44	1.60	7.04	2.36		—	—	—	—	40.46	
DS 24	86.52	3.85	48.47	1.87	6.79	1.47	1.18	—	—	—	39.25	39.55	
NF 550	76.01*	2.55*	42.59	1.22	17.82	2.14	.73	—	.07	.41	34.19	34.86	
D 48	87.32	2.65*	48.88	1.28	10.45	1.14		—	—	—	—	—	
W 311	87.72	2.47	49.16	1.18	7.90	2.74		—	—	—	—	40.08	
W 320	70.52	1.76	39.52	.84	18.06		8.86	—	—	—	—	33.72	
Clay and Shale													
D 34	—	—	—	—	63.20	22.60	2.50	—	—	—	—	7.04	TiO_2–1.04; Moisture–3.36
D 35	—	—	—	—	61.20	24.11	1.89	—	—	—	—	7.20	TiO_2–1.36; Moisture–3.88
Bu 21	—	—	.52	1.73	60.75	20.49	7.30	—	—	—	—	6.05	
Bu 22	—	—	.60	1.58	59.97	21.00	7.15	—	—	—	—	5.54	
Bu 23	—	—	1.14	1.66	59.90	20.27	6.80	—	—	—	—	6.70	
NF 264	—	—	.74	.93	75.50	12.16	4.38	—	1.12	2.10	.09	3.20	
NF 510	—	—	.35	1.06	65.26	18.21	4.97	—	.13	3.32	.00	5.58	TiO_2–.86; FeO–.41; SO_3–.05; V_2O_5–.021
D 56	—	—	—	—	58.06	26.57	1.23	—	—	—	—	9.84	TiO_2–.14; Moisture–4.62
PULASKI COUNTY													
Limestone													
NF 451D	93.51	3.05	52.40	1.46	4.00	.43	.13	—	.03	.03	41.15	41.47	
NF 451A	97.58	1.86	54.68	.89	1.12	.20	.07	—	.00	.05	42.31	43.14	TiO_2–0.00; MnO–.002; P_2O_5–.045; SO_3–.11
NF 451B	96.31	2.49	53.97	1.19	1.71	.18	.08	—	.01	.06	42.91	43.90	TiO_2–0.00; MnO–.002; P_2O_5–.055; SO_3–.14
NF 451C	97.23	1.74	54.48	.83	1.19	.33	.09	—	.02	.02	43.22	43.19	
NF 451E	93.60	3.30	52.45	1.58	2.67	.45	.10	—	.02	.04	42.65	42.70	
D 47	92.90	1.92	52.06	.92	6.38	0.49		—	—	—	—	—	
L 10	94.72	1.50	53.04	.72	1.66	.35	.23	—	—	—	—	—	

Table 5.—

Sample number	Formation	Location					Near	Thickness (ft. in.)	Date†	Remarks
		T.-R.	sec.	¼	¼	¼				
PULASKI COUNTY										
Clay and Shale										
NF 571A	Alluvium	14S–2E	26	SW	SE	SE	Karnak	3	1957[1]	Lower part of exposure
NF 571B	Alluvium	14S–2E	26	SW	SE	SE	Karnak	5	1957[1]	Middle part of exposure
NF 571C	Alluvium	14S–2E	26	SW	SE	SE	Karnak	2	1957[1]	Upper part of exposure
B 4	Cretaceous	14S–2E	27	—	SW	SW	Grand Chain	13	1948[11]	Outcrop and boring
D 45	Cretaceous	15S–1W	15	—	—	—	Pulaski	9	1907[10]	
D 46	Cretaceous	15S–1W	15	—	—	—	Pulaski	5	1907[10]	
D 33	Cretaceous	15S–2E	1	—	—	—	Yates Landing	8	1907[10]	
D 36	Cretaceous	15S–2E	18	—	—	—	Dam 53	—	1907[10]	
D 44	Devonian	15S–1W	31	—	—	—	Unity	10	1907[10]	Boring in flat of Cache River
NF 496	Loess	16S–1W	7	SW	SW	SW	Unity	20	1957[1]	
La 3	Porters Creek	15S–1E	26	SW	NW	NW	Olmsted	15	1948[11]	Lower part of formation
Fe 116	Porters Creek	15S–1E	27	NE	NE	SE	Olmsted	10	1948[11]	
SALINE COUNTY										
Limestone										
NF 545D	Kincaid	10S–7E	3	SE	SW	NW	Somerset	20	1956[1]	Cave Hill quarry; shale. Sample NF 545A from same deposit
UNION COUNTY										
Limestone										
NF 444	Backbone	11S–3W	23	NE	SW	NE	Wolf Lake	40	1946[2]	Bluff of Hutchins Creek
NF 91	Bailey	11S–3W	4	N½	SW	SE	Aldridge	45	1933[7]	Lower 45′ in river bluff
NF 92	Bailey	11S–3W	4	N½	SW	SE	Aldridge	50	1933[7]	Upper 45′ in river bluff
La 7	Bailey	11S–3W	21	—	—	NE	LaRue	60	1933[7]	
NF 70	Bailey	12S–3W	3	SE	NW	NW	Wolf Lake	60	1933[7]	
NF 93	Bailey	13S–2W	20	C	N½	N½	Reynoldsville	30	1933[7]	Lower 30′ in river bluff
NF 94	Bailey	13S–2W	20	C	N½	N½	Reynoldsville	100	1933[7]	Upper 100′ in river bluff
NF 515L	Golconda	11S–2W	25	S½	NE	SE	Mountain Glen	7 9	1955[1]	Limestone in 13½′ exposure; balance of outcrop is shale. See Sample NF 515S
NF 535L	Golconda	13S–1E	2	NE	NW	SE	Mt. Pleasant	8 6	1955[1]	Limestone in 49′ 5″ exposure; balance of outcrop is shale. See NF 535S
NF 457	Grand Tower	11S–2W	34	NW	NW	NE	Mountain Glen	22	1951[1]	Road cut
NF 532	Kinkaid	11S–1E	20	SE	NW	SE	Lick Creek	19	1955[1]	Abandoned quarry
NF 531	Menard	11S–1W	36	NE	NW	NW	Saratoga	22	1955[1]	Abandoned quarry; 3 covered intervals
L 20	Paint Creek	12S–1W	8	—	N½	NE	Anna	18	1928[2]	
NF 529	St. Louis	12S–1W	18	—	NE	SW	Anna	31	1955[1]	From two outcrops separated by a 25-foo covered zone
NF 533	St. Louis	13S–1W	17	Center			St. Johns Church	17	1955[1]	Road cut
NF 174A	Ste. Genevieve (Fredonia M.)	12S–1W	20	SE	NW	NE	Anna	7 4	1934[2]	Anna Quarries, Inc.; 0′ to 7′ 4″ above base
NF 174C	Ste. Genevieve (Fredonia M.)	12S–1W	20	SE	NW	NE	Anna	25 10	1934[2]	Anna Quarries, Inc.; 20′ 6″ to 46′ 4″
NF 174E	Ste. Genevieve (Fredonia M.)	12S–1W	20	SE	NW	NE	Anna	26 3	1934[2]	Anna Quarries, Inc.; 49′ 6″ to 75′ 9″
NF 516	Warsaw-Salem	12S–2W	2	SE	SW	NW	Kaolin	39	1955[1]	Cut along G.M. and O. Railroad
L 1	Warsaw-Salem	12S–2W	2	—	—	W½	Kaolin	60	1928[2]	Tunnel cut
NF 443	Warsaw-Salem	13S–1W	17	NE	SW	SW	Mill Creek	50	1946[2]	Jonesboro Stone Company
NF 568	Warsaw-Salem	13S–1W	18	SW	SW	NW	Mill Creek	22	1957[1]	Road cut
NF 565A	Warsaw-Salem	13S–1W	20	SW	SW	SE	Mill Creek	100	1954[1]	Pure Limestone Company, diamond drill core, 78′ to 177′ deep
NF 565B	Warsaw-Salem	13S–1W	20	SW	SW	SE	Mill Creek	100	1954[1]	Pure Limestone Co.; 178′ to 278′
NF 565C	Warsaw-Salem	13S–1W	20	SW	SW	SE	Mill Creek	100	1954[1]	Pure Limestone Co.; 278′ to 378′

(Continued)

Sample number	$CaCO_3$	$MgCO_3$	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	R_2O_3	Na_2O	K_2O	CO_2	Ignition loss	Other components
PULASKI COUNTY													
Clay and Shale													
NF 571A	—	—	8.02	3.92	52.39	14.87	5.16	—	.43	2.99	8.43	12.23	
NF 571B	—	—	.97	.31	67.07	17.12	5.19	—	.62	2.61	.12	5.41	
NF 571C	—	—	4.43	2.75	58.95	16.86	5.44	—	.52	2.95	4.17	8.67	
B 4	—	—	.44	.77	59.60	26.48	2.39	—	.37	1.67	—	8.03	TiO_2–.72
D 45	—	—	—	—	62.76	22.36	3.07	—	—	—	—	6.12	TiO_2–.97; Moisture–2.99
D 46	—	—	—	—	57.14	25.52	2.82	—	—	—	—	8.12	TiO_2–1.08; Moisture–3.48
D 33	—	—	—	—	67.54	21.54	1.70	—	—	—	—	6.29	TiO_2–.78; Moisture–2.48
D 36	—	—	—	—	68.26	20.87	2.03	—	—	—	—	5.56	TiO_2–1.14; Moisture–1.90
D 44	—	—	—	—	69.92	20.19	1.21	—	—	—	—	6.35	TiO_2–.98; Moisture–1.11
NF 496	—	—	4.32	2.67	69.25	10.16	3.06	—	1.33	2.12	4.94	6.98	
La 3	—	—	.85	1.79	69.07	11.87	4.36	—	.00	1.40	.03	10.21	TiO_2–.84; S–0.0
FE 116	—	—	.86	2.00	61.06	15.99	4.50	—	.07	1.43	—	13.36	TiO_2–.21; FeO–.12; P_2O_5–.36
SALINE COUNTY													
Limestone													
NF 545D	86.54*	2.13*	48.49	1.02	8.61	1 57	.76	—	.07	.26	38.63	39.21	
UNION COUNTY													
Limestone													
NF 444	95.98*	3.78*	53.77	1.81	0.68	.30	.10	—	.09	.04	43.61	43.60	SO_3–.04; MnO–.030; P_2O_5–.009
NF 91	54.20*	4.81*	30.37	2.30	37.25	3.21	1.12	—	—	—	—	25.48	
NF 92	47.86*	5.89*	26.82	2.82	41.44	3.93	1.10	—	—	—	—	23.47	
La 7	58.14	4 75	32.58	2.27*	33.58	1.03	1.21	—	—	—	28.05	—	
NF 70	56.22*	6.06*	31.5	2.9	36.3	2.18	1.42	—	—	—	—	26.7	
NF 93	61.66*	3.45*	34.55	1.65	31.53	2.96	1.07	—	—	—	—	27.99	
NF 94	59.27*	6.06*	33.21	2.90	31.81	2.64	1.74	—	—	—	—	28.35	
NF 515L	75.80*	2.64*	42.48	1.26	17.07	3.44	1.08	—	.05	.57	33.62	34.73	
NF 535L	89.53*	1.67*	50.17	.80	6.12	1.37	1.03	—	.05	.12	40.03	40.37	
NF 457	97.56*	1.63*	54.67	.78	1.09	.28	.11	—	.02	.03	43.20	43.32	MnO–.024; P_2O_5–.017; SO_3–.09
NF 532	85.13*	7.42*	47.70	3.55	4.43	1.18	1.25	—	.03	.20	41.05	41.46	
NF 531	92.34*	2.64*	51.74	1.26	3.46	.87	.67	—	.06	.07	41.60	41.81	
L 20	87.56	4.00	49.03	1.91	7.34	.42	.64	—	—	—	—	—	
NF 529	85.95	10.29	48.16	4.92	3.44	.64	.20	—	.03	.07	42.53	42.85	
NF 533	68.19	11.29	38.21	5.40	18.79	1.23	.40	—	.03	.16	35.38	35.60	
NF 174A	97.30	1.33	54.52	.64	1.07	.50	.29	—	—	—	43.28	43.06	
NF 174C	93.10	5.44	52.17	2.60	1.82	.68	.33	—	—	—	43.69	43.04	
NF 174E	93.98	4.83	52.65	2.31	2.10	.45	.33	—	—	—	43.32	42.94	
NF 516	97.33	1.71	54.54	.82	1.36	.19	.09	—	.03	.02	43.25	43.18	MnO–.008; P_2O_5–.046; SO_3–.03; SrO–.034
L 1	96.70	.73	54.15	.35	.72	.20	.10	—	—	—	—	—	
NF 443	99.10	1.46	55.53	.70	.29	.26	.11	—	.07	.02	43.42	43.23	MnO–.005; SO_3–.15; P_2O_5–.046
NF 568	95.99	3.66	53.79	1.75	.76	.31	.12	—	—	—	—	43.61	
NF 565A	98.83	.86	55.38	.41	.42	.31	.09	—	.02	.02	43.51	43.66	MnO–.005; P_2O_5–.025; SO_3–.08
NF 565B	98.99	1.25	55.47	.60	.36	.29	.09	—	.03	.02	43.66	43.68	MnO–.004; P_2O_5–.036; SO_3–.06
NF 565C	95.71	4.35	53.63	2.08	.58	.17	.09	—	.02	.02	43.79	43.84	MnO–.005; P_2O_5–.041; SO_3–.07

TABLE 5.—

Sample number	Formation	Location T.-R.	sec.	¼	¼	¼	Near	Thickness (ft.	in.)	Date†	Remarks
							UNION COUNTY				
							Limestone				
NF 565D	Warsaw-Salem	13S-1W	20	SW	SW	SE	Mill Creek	29		1954[1]	Pure Limestone Co.; 378′ to 408′
NF 565E	Warsaw-Salem	13S-1W	20	SW	SW	SE	Mill Creek	26		1954[1]	Pure Limestone Co.; 420′ to 446′
W 285	Warsaw-Salem	13S-2W	1	—	NE	SE	Kornthal Station	40		1912[3]	Scattered chert nodules
NF 527	Warsaw-Salem	13S-2W	1	NW	NE	SE	Kornthal Church	28		1955[1]	Abandoned quarry; chert present, not included in sample
							Clay and Shale				
NF 569	"Alluvium"	12S-2W	32	SW	SE	NW	Ware	5		1957[1]	
D 11	Cretaceous	11S-2W	35	—	—	—	Kaolin	4		1907[10]	40′ to 44′ below surface
D 12	Cretaceous	11S-2W	35	—	—	—	Kaolin	5		1907[10]	35′ to 40′ below surface
D 13	Cretaceous	11S-2W	35	—	—	—	Kaolin	—		1907[10]	From stock crib; yellowish
D 14	Cretaceous	11S-2W	35	—	—	—	Kaolin	—		1907[10]	From stock crib; white
R 83	Cretaceous	11S-2W	35	—	—	—	Kaolin	—		1933[9]	Purified by sedimentation
AK	Cretaceous	11S-2W	35	NE	SW	NW	Kaolin	—		1948[11]	Sample from storage bin of Boyd pit
D 10	Cretaceous	11S-2W	35	—	—	—	Kaolin	34		1907[10]	More than 50′ below surface
NF 515S	Golconda	11S-2W	25	S½	NE	SE	Mountain Glen	4	8	1955[1]	Shale with interbedded limestone in 13½′ exposure; balance of outcrop limestone. See Sample NF 515L
NF 535S	Golconda	13S-1E	2	NE	NW	SE	West Vienna	40	11	1955[1]	Shale with limestone lenses in 49′ 5″ exposure; balance of outcrop limestone. See Sample NF 535L
L 10	Loess	12S-1W	17	—	—	—	Anna	—		1912[3]	
10	New Albany	12S-2W	11	—	—	SW	Mountain Glen	10		1921[8]	Along Caney Creek; lower 10′
11	New Albany	12S-2W	11	—	—	SW	Mountain Glen	25		1921[8]	Along Caney Creek; upper 25′
NF 517	New Albany	11S-2W	34	SE	NE	NE	Mountain Glen	28		1957[1]	35′ to 68′ above creek
1	New Albany	12S-2W	23	—	NW	NE	Jonesboro	20		1940[1]	
L 11	Renault	12S-1W	6	—	—	—	Cobden	10		1912[3]	
L 16	Renault	12S-1W	9	SW	NE	SW	Anna	16		1934[7]	
NF 514 A-1	Springville	12S-2W	23	W½	NE	NE	Jonesboro	15		1955[1]	Upper brown shale
NF 514 A-2	Springville	12S-2W	23	W½	NE	NE	Jonesboro	10		1955[1]	Lower gray shale
W 286	Springville	13S-2W	1	—	NE	SE	Springville	40		1912[3]	
LM 14	Springville	13S-2W	26	NE	SE	NE	Mill Creek	10		1948[11]	Along Lingle Creek
NF 413	Springville	13S-2W	26	NW	NW	NE	Mill Creek	7		1948[11]	Along tributary Lingle Creek; calico shale
NF 541	Springville	13S-2W	26	SE	SW	NE	Jonesboro	29		1955[1]	Bluff along creek

†Date when sample was taken; if sampling date is not known, the date given is that of the publication of the analysis.
*Data calculated by writer from other data in the analysis.
**Identity of beds uncertain, but probably Fredonia.
[1] Analysis made by L. D. McVicker in laboratories of Illinois State Geological Survey.
[2] Lamar, J. E., 1957, Chemical analyses of Illinois limestones and dolomites: Illinois Geol. Survey. Rept. Inv. 200.
[3] Bleininger, A. V., Lines, E. F., and Layman, F. E., 1912, Portland cement resources of Illinois: Illinois Geol. Survey Bull. 17, p. 97-100, 104, 111, 113.
[4] Krey, Frank, and Lamar, J. E., 1925, Limestone resources of Illinois: Illinois Geol. Survey Bull. 46, p. 312-333.
[5] Lamar, J. E., Machin, J. S., Voskuil, W. H., and Willman, H. B., 1956, Preliminary report on Portland cement materials in Illinois: Illinois Geol. Survey Rept. Inv. 195, p. 28-31.
[6] Analysis by Chemistry Department, University of Illinois.

(Continued)

Sample number	$CaCO_3$	$MgCO_3$	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	R_2O_3	Na_2O	K_2O	CO_2	Ignition loss	Other components
						UNION COUNTY							
						Limestone							
NF 565D	90.60	8.22	50.77	3.93	1.20	.57	.15	—	.02	.03	43.49	43.78	
NF 565E	88.91	8.14	49.82	3.89	2.98	.37	.13	—	.02	.03	42.67	42.98	
W 285	92.46	2.97	51.82	1.42	3.30	1.48		—	—	—	—	42.32	
NF 527	96.78	2.17	54.23	1.04	1.37	.35	.27	—	.02	.02	43.16	43.21	
						Clay and Shale							
NF 569	—	—	.78	.59	79.23	10.63	2.74	—	.91	1.76	.06	2.95	
D 11	—	—	—	—	48.30	31.14	1.02	—	—	—	—	15.37	TiO_2–3.20; Moisture–.97
D 12	—	—	—	—	56.55	29.97	1.23	—	—	—	—	8.64	TiO_2–2.75; Moisture–.86
D 13	—	—	—	—	47.95	37.86	1.23	—	—	—	—	9.05	TiO_2–3.01; Moisture–.90
D 14	—	—	—	—	52.65	33.98	0.97	—	—	—	—	10.61	TiO_2–2.92; Moisture–.87
R 83	—	—	1.02	.84	48.18	30.72	1.59	—	.01	.29	—	14.11	TiO_2–1.20; FeO–.40; P_2O_5–.90
AK	—	—	.15	.37	51.10	34.01	1.41	—	.36	.31	—	11.95	TiO_2–.95
D 10	—	—	—	—	43.90	40.79	1.76	—	—	—	—	9.90	TiO_2–2.40; Moisture–1.25
NF 515S	—	—	32.87	1.28	28.94	6.67	1.55	—	.08	1.21	25.84	27.93	
NF 535S	—	—	30.10	1.49	27.83	9.83	2.95	—	.12	1.41	23.61	26.61	
L 10	—	—	2.12	2.18	73.10	13.45	5.33	—	—	—	—	2.86	
10	—	—	0.8	1.6	53.7	16.3	5.7	—	0.5	5.0	—	12.7	
11	—	—	0.2	1.1	56.4	15.2	5.6	—	0.6	4.3	—	14.5	
NF 517	—	—	.18	1.39	62.71	13.16	4.44	—	.15	4.39	.00	12.32	SO_3–.84; V_2O_5–.071; TiO_2–.74
1	—	—	.70	1.83	56.88	13.88	5.72	—	.57	4.19	—	15 90	TiO_2–.75
L 11	—	—	1.43	1.69	64.78	18.17	6.74	—	—	—	—	5.62	
L 16	—	—	14.06	2.01	45.54	17.85	—	—	—	—	—	—	
NF 514 A-1	—	—	.19	1.05	81.47	10.00	2.78	—	.15	2.38	.00	2.69	
NF 514 A-2	—	—	1.34	1.46	74.71	11.97	3.36	—	.16	3.37	1.03	4.10	
W 286	—	—	5.32	1.50	71.24	13.74		—	—	—	—	7.66	
LM 14	—	—	.10	.79	78.63	11.36	2.33	—	.11	2.88	.04	3.38	TiO_2–.60
NF 413	—	—	.33	.97	77.88	12.85	1.61	—	.17	2.60	—	3.44	TiO_2–.66; MnO–.008
NF 541	—	—	.40	1.78	73.38	12.93	2.64	—	.19	3.68	.11	3.56	TiO_2–.59; FeO–1.16; SO_3–.07; V_2O_5–.036

[7]Lamar, J. E., Willman, H. B., Fryling, C. F., and Voskuil, W. H., 1934, Rock wool from Illinois mineral resources: Illinois Geol. Survey Bull. 61, p. 61, 118, 150.

[8]Parr, S. W., and Austin, M. M., 1921, Potash shales of Illinois: Univ. Illinois Agr. Exp. Station, Bull. 232, p. 236; Krey, Frank, 1920, Geology, distribution and occurrence of the potash shales of Union County: Illinois Geol. Survey unpublished manuscript. Analyses recalculated.

[9]Piersol, R. J., Lamar, J. E., and Voskuil, W. H., 1933, Anna kaolin as a new decolorizing agent for vegetable oils: Illinois Geol. Survey Rept. Inv. 27, p. 25.

[10]Purdy, R. C., and DeWolf, F. M., 1907, Preliminary investigation of Illinois fireclays: Illinois Geol. Survey Bull. 4, p. 149-153, 155-159, 173, 175.

[11]Lamar, J. E., 1948, Clay and shale resources of extreme Southern Illinois: Illinois Geol. Survey Rept. Inv. 128, p. 18, 19.

Table 6.—Table of Physical Tests

County	Sample number*	Location T.-R.	sec.	¼	¼	Near	Formation	Thickness sampled (ft.)	Specific gravity	Absorption (%)	Los Angeles abrasion loss—%	Sodium sulfate soundness loss—%	Remarks
Alexander	NF 522	15S–3W	17	NW	SE	Thebes	Kimmswick	13½	2.66	0.5	45.6	4.27	Railroad cut
Alexander	NF 512	15S–3W	21	SE	NW	Thebes	Girardeau	19½	2.70	0.4	25.1	3.28	Outcrop
Alexander	NF 526	14S–3W	12	SE	NW	McClure	St. Clair	23½	2.69	0.3	23.7	3.23	Outcrop
Hardin	NF 546	11S–7E	25	SW	SW	Eichorn	Warsaw-Salem	32	2.68	0.2	19.1	1.44	Stream bed, parts of deposit are cherty, chert not included in sample
Hardin	NF 555D	12S–7E	35	Cen.	SW	Shetlerville	Levias Member	15½	2.68	0.6	27.2	6.15	Abandoned quarry
Hardin	NF 548A	12S–8E	14	Cen.	SE	Elizabethtown	Ste. Genevieve	23	2.66	1.1	30.2	6.05	Road cut
Hardin	NF 548C	12S–8E	14	Cen. line	E.	Elizabethtown	Ste. Genevieve	40	2.70	0.8	24.5	9.47	Road cut
Hardin	NF 511, Unit 2	12S–8E	27	SW	SW	Elizabethtown	Ste. Genevieve	14	2.71	0.7	21.9	2.90	6′ to 20′ below top of quarry
Hardin	NF 511, Unit 3	12S–8E	27	SW	SW	Elizabethtown	St. Louis	14½	2.72	0.4	23.7	4.22	20′ to 34½′ below top of quarry
Hardin	NF 511, Unit 4	12S–8E	27	SW	SW	Elizabethtown	St. Louis	17	2.71	0.3	23.1	1.26	34½′ to 51½′ below top of quarry
Hardin	NF 511, Unit 5	12S–8E	27	SW	SW	Elizabethtown	St. Louis	16	2.70	0.3	24.6	4.03	51½′ to 67½′ below top of quarry
Hardin	NF 511, Unit 6	12S–8E	27	SW	SW	Elizabethtown	St. Louis	6½	2.68	0.4	29.3	7.50	67½′ to 74′ below top of quarry
Johnson	NF 556C	12S–4E	23	SW	NE	Simpson	Kinkaid	17	2.68	0.5	28.9	2.04	Abandoned quarry
Johnson	NF 560	13S–3E	32	SE	SW	Belknap	Renault	13½	2.68	0.6	36.0	4.67	Railroad cut
Johnson	NF 521	13S–4E	12	SW	NE	Grantsburg	Vienna	20½	2.66	0.7	19.8	3.69	Chert in deposit not included in sample
Massac	NF 552L	11S–3E	3	NW	NW	Vienna	Renault	21	2.68	0.6	28.4	5.08	Abandoned quarry; limestone from 34′ outcrop of limestone and shale
Pope	NF 550	13S–5E	14	SW	NE	Dixon Springs	Kinkaid	30	2.67	0.5	23.2	3.31	Abandoned quarry
Union	NF 519	11S–2W	34	NW	NE	Mountain Glen	Grand Tower	15	2.70	0.3	25.9	2.26	Road cut
Union	NF 516	12S–2W	2	SW	NW	Mountain Glen	Warsaw-Salem	47	2.58	1.3	23.1	7.03	Railroad cut
Union	NF 527	13S–2W	1	NE	SE	Jonesboro	Warsaw-Salem	28	2.51	1.7	28.9	8.85	Old quarry; about 10% chert in deposit not included in sample
Union	NF 529	12S–1W	18	NE	SW	Anna	St. Louis	31	2.66	1.0	27.6	6.98	Outcrop and old quarry
Union	NF 533	13S–1W	17	Center		Springville	St. Louis	17	2.62	1.3	21.9	8.81	Road cut
Union	NF 532	11S–1E	20	NW	SE	Lick Creek	Kinkaid	19	2.71	0.8	23.6	10.01	Old quarry

* All the above samples, except NF 522 and NF 560, are satisfactory for portland cement concrete and higher types of bituminous road surfacings. Sample NF 522 is too soft and Sample NF 560 is of borderline quality for these purposes because its Los Angeles abrasion loss is above the permissible maximum of the Bureau of Materials, Illinois Division of Highways. Tests by the Bureau of Materials, Illinois State Division of Highways Testing Laboratory, Springfield, Illinois, 1955, 1956, and 1957.

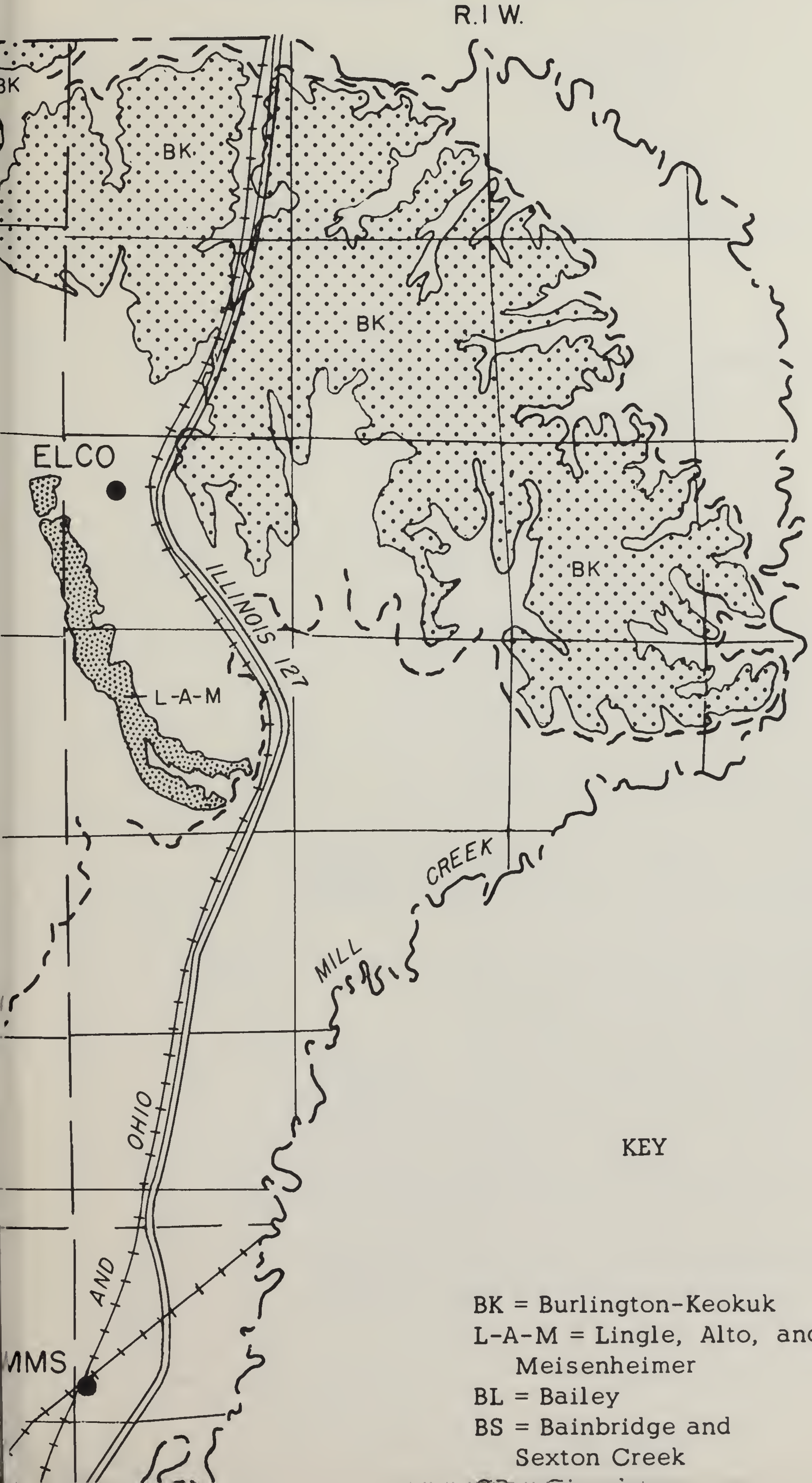
TABLE 7.—EARLIER PHYSICAL TESTS OF LIMESTONES

County	Reference number	Location	Formation	Company	Specific gravity	Wt. per cu. ft.	Absorption		Percent of wear	Coefficients			Cementing value
							Per-cent	Lbs. per cu. ft.		French	Hard-ness	Tough-ness	
Alexander	1443[1]	Near Ullin	Burlington-Keokuk*		—	162	—	.50	5.8	6.9	19.4	7	15
Hardin	KX[2]	12S-7E, sec. 35, SE NE	Ste. Genevieve		2.69	168	.17	.28	—	9.3	17.2	14	60
Hardin	[2]	Shetlerville	Ste. Genevieve	Golconda Portland Cement Co.	2.70	168	.17	—	—	9.3	12.7	6	44
Johnson	K29[2]	12S-3E, sec. 16, S. cen.	Kinkaid		2.68	167	.33	.57	—	10.0	16.6	12	73
Johnson	K32[2]	12S-2E, 33, SW	Menard		2.70	168	.23	.40	—	12.1	16.1	10	216
Johnson	6598[1]	Near Vienna	Vienna?		—	165	—	.73	3.8	10.5	17.8	20	73
Johnson	7007[1]	Whitehill	Ste. Genevieve	Charles Stone Company	—	168	—	.34	6.8	5.9	13 9	4	51
Johnson	590[3]	Whitehill	Ste. Genevieve	Charles Stone Company	2 69	168	—	.71	4.4	9.1	—	8	—
Johnson	7509[1]	Reevesville	Menard?		—	168	—	.27	5.1	7.8	15 7	6	79
Johnson	7510[1]	Reevesville	Menard?		—	168	—	.34	4.1	9.7	16.3	6	55
Johnson	7617[1]	Cypress	Renault?		—	168	—	.59	3.9	10.2	15 2	7	21
Pulaski	450[1]	Ullin	Burlington-Keokuk?*		—	156	—	3.79	5.6	7 2	—	—	—
Union	3225[1]	Anna	Ste. Genevieve		—	168	—	.61	4 2	9 5	—	—	15
Union	5549[1]	Anna	Ste. Genevieve		—	168	—	.42	3 3	12 0	14 3	9	16
Union	7623[1]	Anna	Ste. Genevieve		—	165	—	1.08	5 0	8 1	15 3	5	58
Union	1110[3]	Anna	Ste. Genevieve	C. F. Massey Company	2.69	167	—	.82	3.9	10 2	—	18	—
Union	K71[2]	Tunnel cut, 12S-2W, sec. 2	Warsaw-Salem		2.61	163	.8	1.3	4 9	8.2	14 7	8	36

[1]Hubbard, Prevost, and Jackson, F. H., Jr., 1916, Results of physical tests on road-building rock: U. S. Dept. Agr. Bull. 370, p. 23-26.
[2]Krey, Frank, and Lamar, J. E., 1925, Limestone resources of Illinois: Illinois Geol. Survey Bull. 46, p. 47-62.
[3]Fifth Report, Illinois State Highway Dept., 1917, p. 252-256.
*Cherty limestone or siliceous limestone.

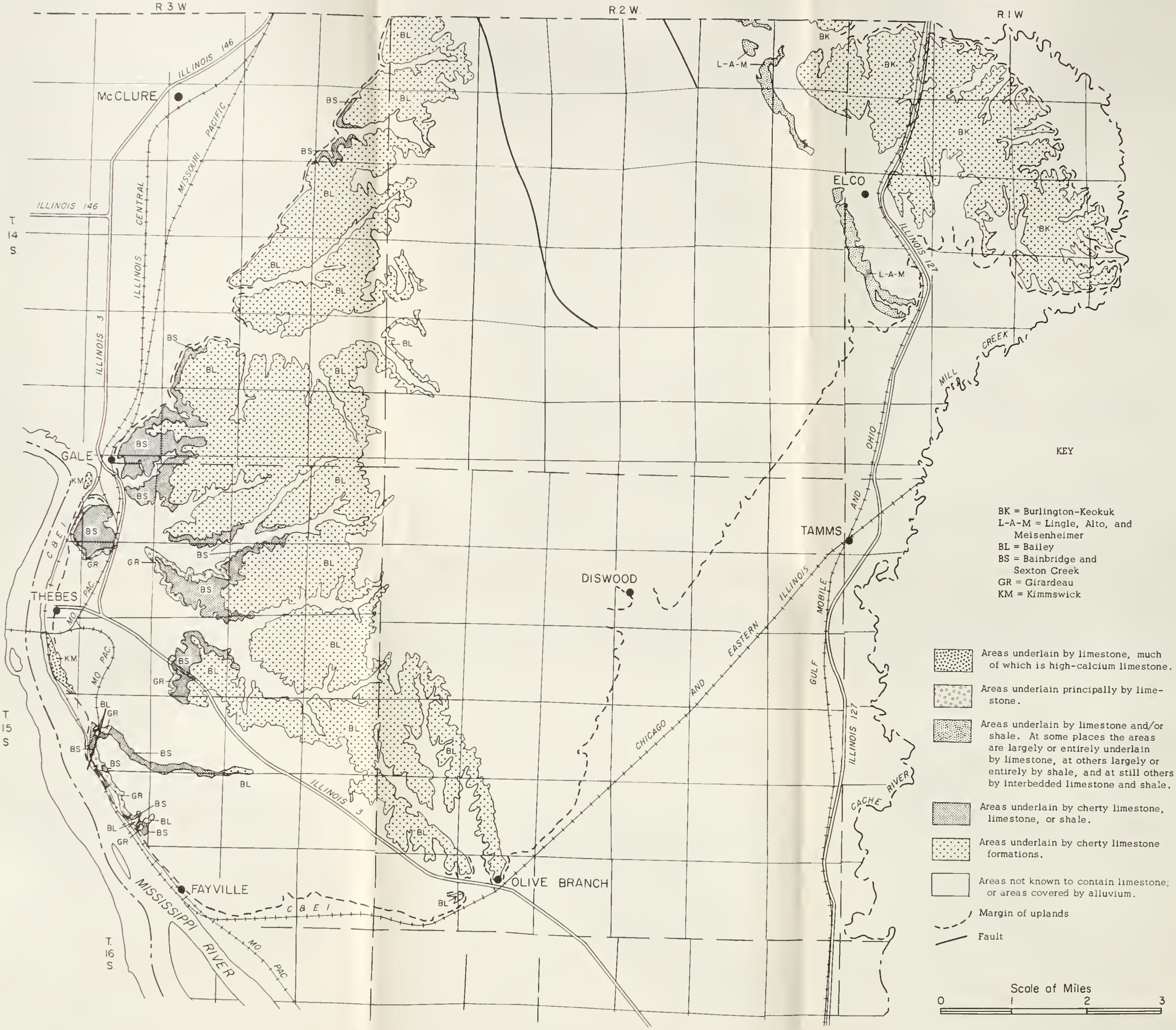
Illinois State Geological Survey Report of Investigations 211
81 p., 4 figs., 8 pls., 7 tables, 1959

Report of Investigations 211 – Plate 1



KEY

BK = Burlington-Keokuk
L-A-M = Lingle, Alto, and Meisenheimer
BL = Bailey
BS = Bainbridge and Sexton Creek



LIMESTONE RESOURCES IN ALEXANDER COUNTY

J. E. LAMAR

1958

Modified from J. M. Weller, and G. E. Ekblaw, 1940


V-W-M
LAMB
GD
V-W-M
V-W-M
G
GD
GD
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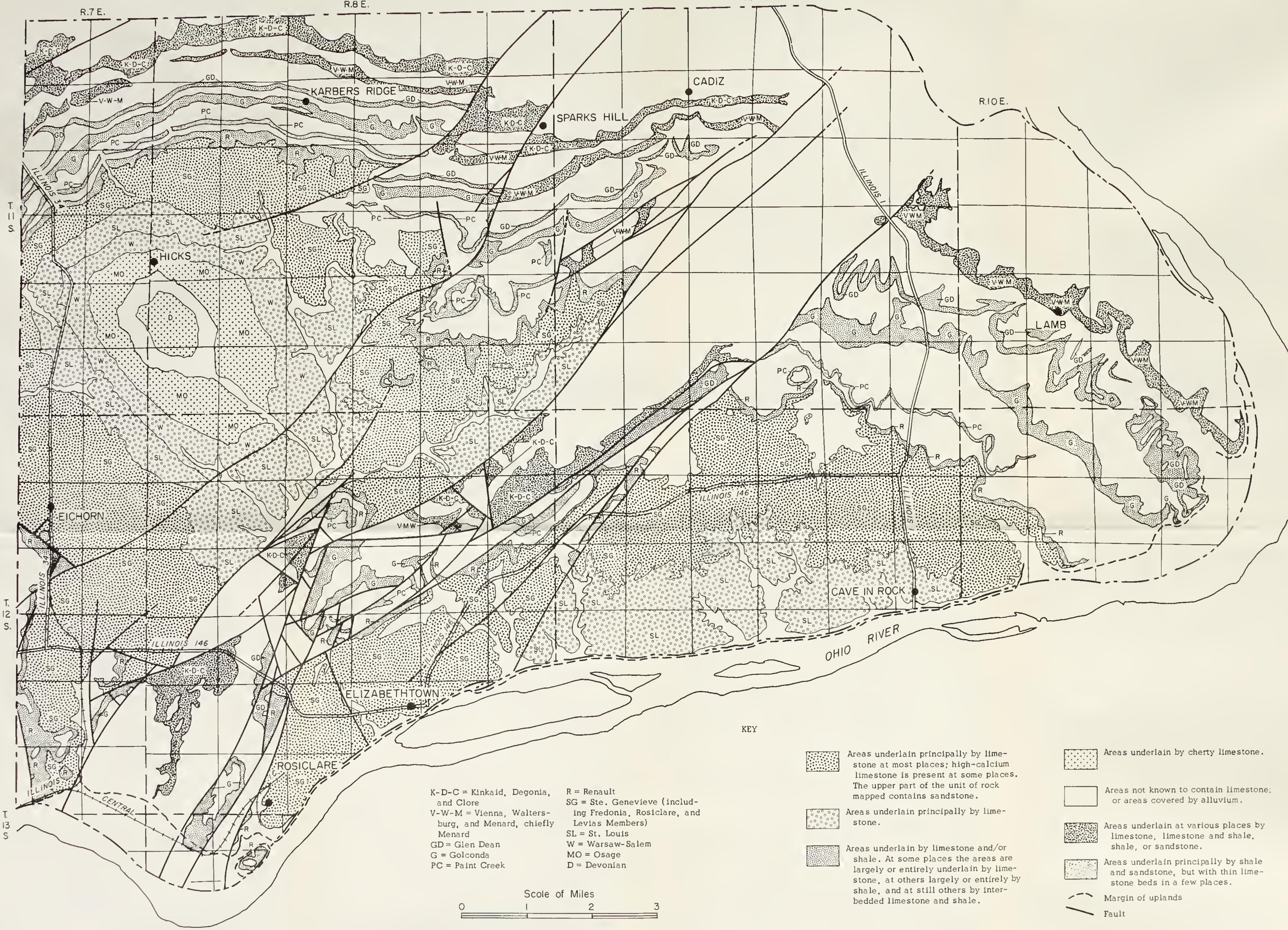
G

Illinois State Geological Survey

Report of Investigations 211 - Plate 2



K-D-C = Kinkaid, Degonia, and Clore
V-W-M = Vienna, Waltersburg, and Menard, chiefly Menard
GD = Glen Dean
G = Golconda
PC = Paint Creek
R = Renault
SG = Ste. Genevieve (including Fredonia, Rosiclare, and Levias Members)
SL = St. Louis
W = Warsaw-Salem
MO = Osage
D = Devonian

Scale of Miles
0 1 2 3

KEY

Areas underlain principally by limestone at most places; high-calcium limestone is present at some places. The upper part of the unit of rock mapped contains sandstone.

Areas underlain principally by limestone.

Areas underlain by limestone and/or shale. At some places the areas are largely or entirely underlain by limestone, at others largely or entirely by shale, and at still others by interbedded limestone and shale.

Areas underlain by cherty limestone.

Areas not known to contain limestone; or areas covered by alluvium.

Areas underlain at various places by limestone, limestone and shale, shale, or sandstone.

Areas underlain principally by shale and sandstone, but with thin limestone beds in a few places.

Margin of uplands

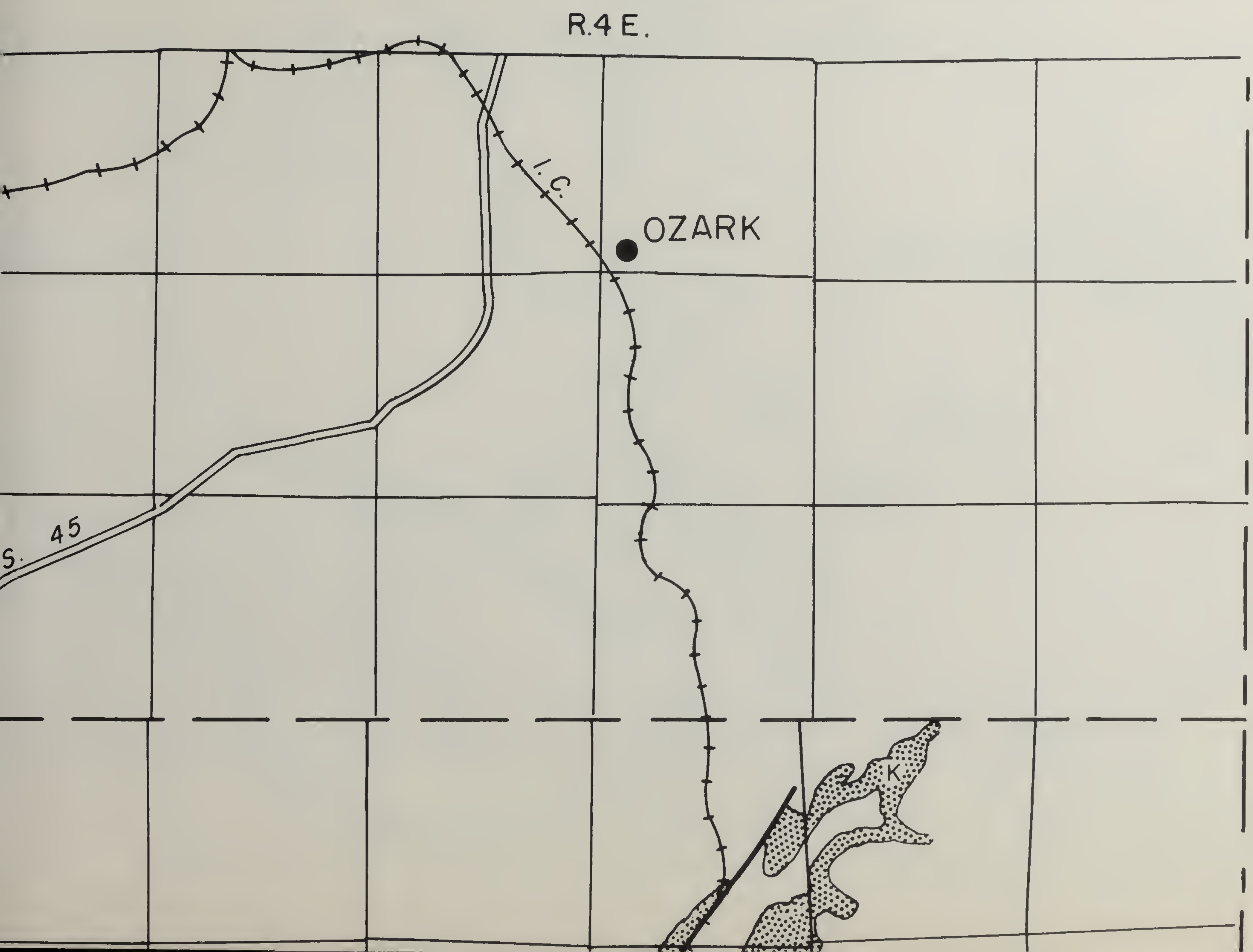
Fault

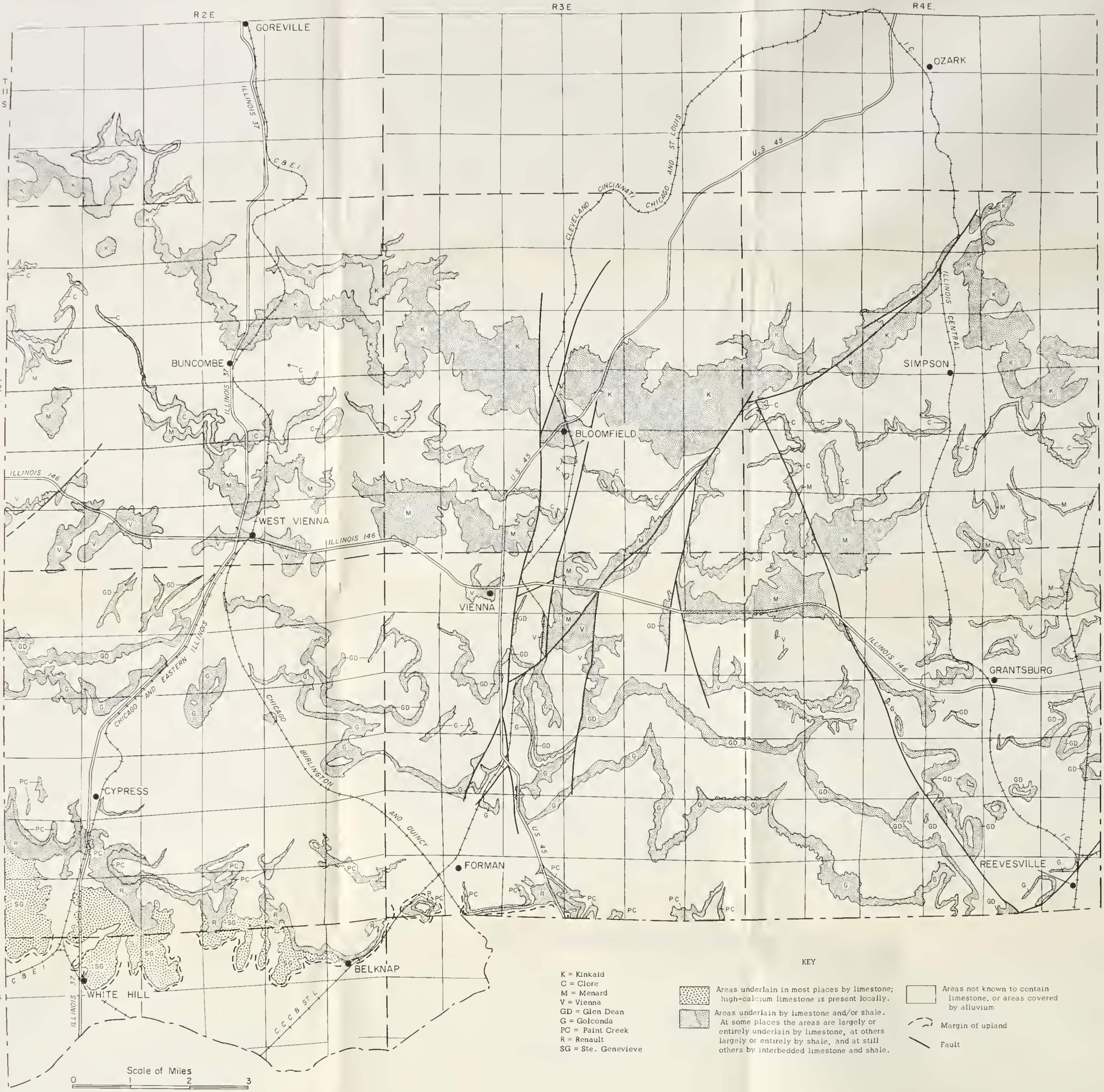
LIMESTONE RESOURCES IN HARDIN COUNTY

J. E. LAMAR

1958

Modified from S. Weller, 1920, with minor adaptations from another geological map of Hardin county, J. M. Weller, R. M. Grogan and F. E. Tippie, 1952


R.4 E.
I.C.
OZARK
S. 45
K



LIMESTONE RESOURCES IN JOHNSON COUNTY

J. E. LAMAR

1958

Modified from S. Weller, and F. Krey, 1939; J. E. Lamar, 1925; and unpublished maps of M Fuller and G H Cady

211—Plate 4-A

MASSAC COUNTY

KEY

Areas underlain by limestone at most places; high-calcium limestone probably is present locally. Cherty limestone may also occur in some places.

Areas underlain by limestone and/or shale. At some places the areas are largely or entirely underlain by limestone, at others largely or entirely by shale, and at still others by interbedded limestone and shale.

Areas not known to contain limestone; or areas covered by alluvium.

Margin of uplands

Identification of Units Mapped

M = Menard
GD = Glen Dean
G = Golconda
PC = Paint Creek
R = Renault
SG = Ste. Genevieve

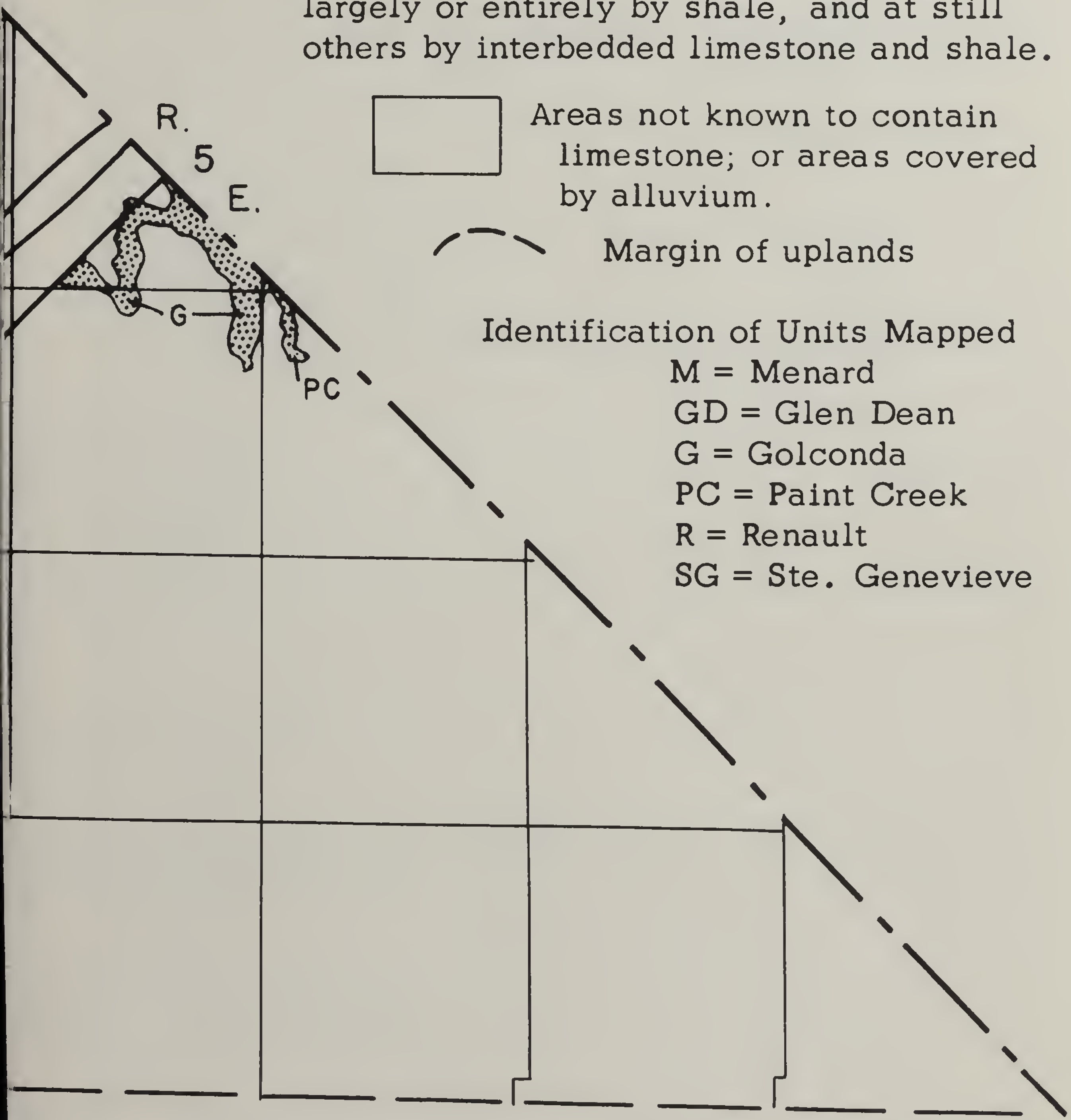


Plate 4-B

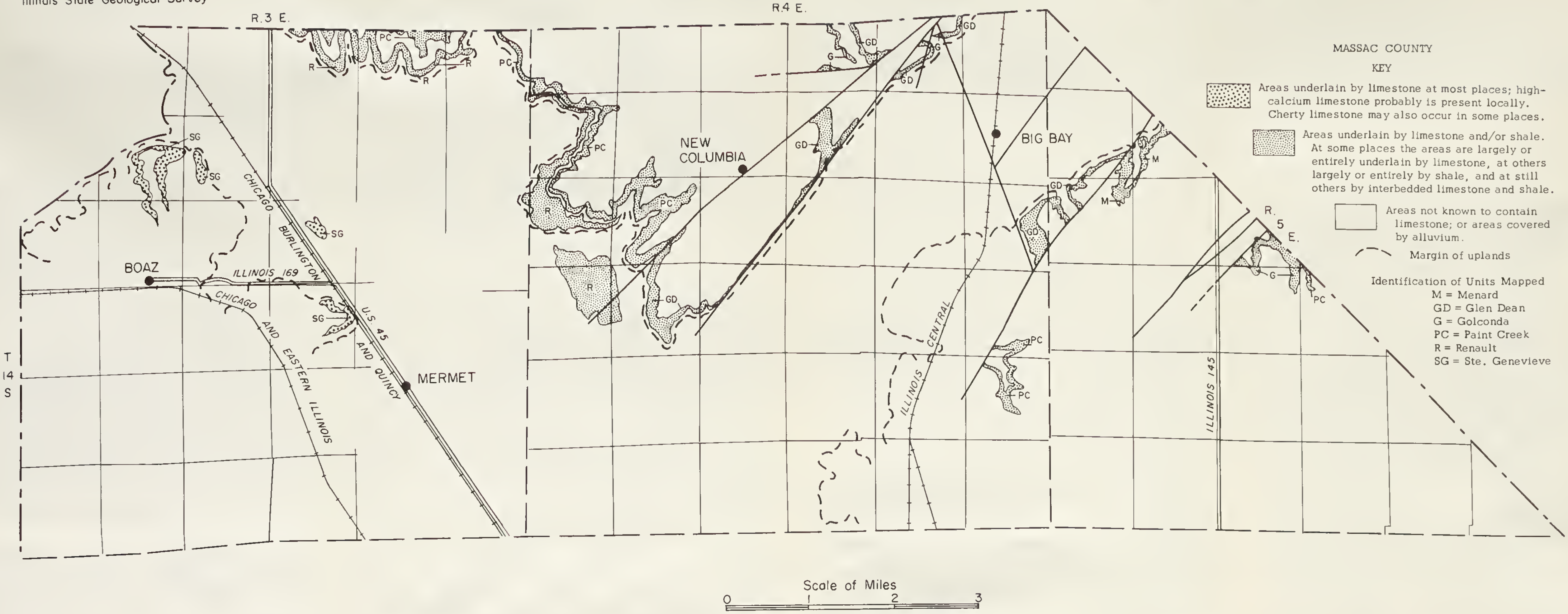
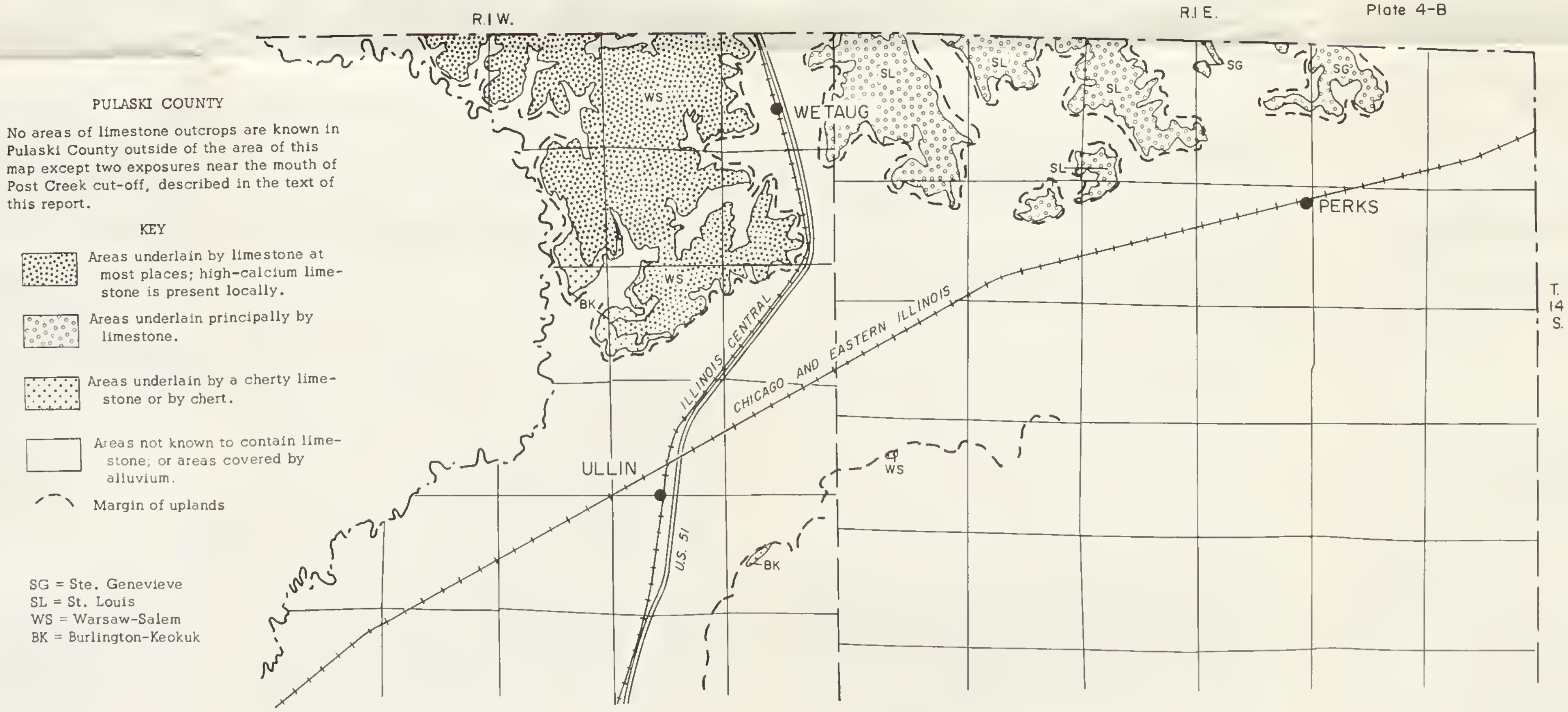


Plate 4-B



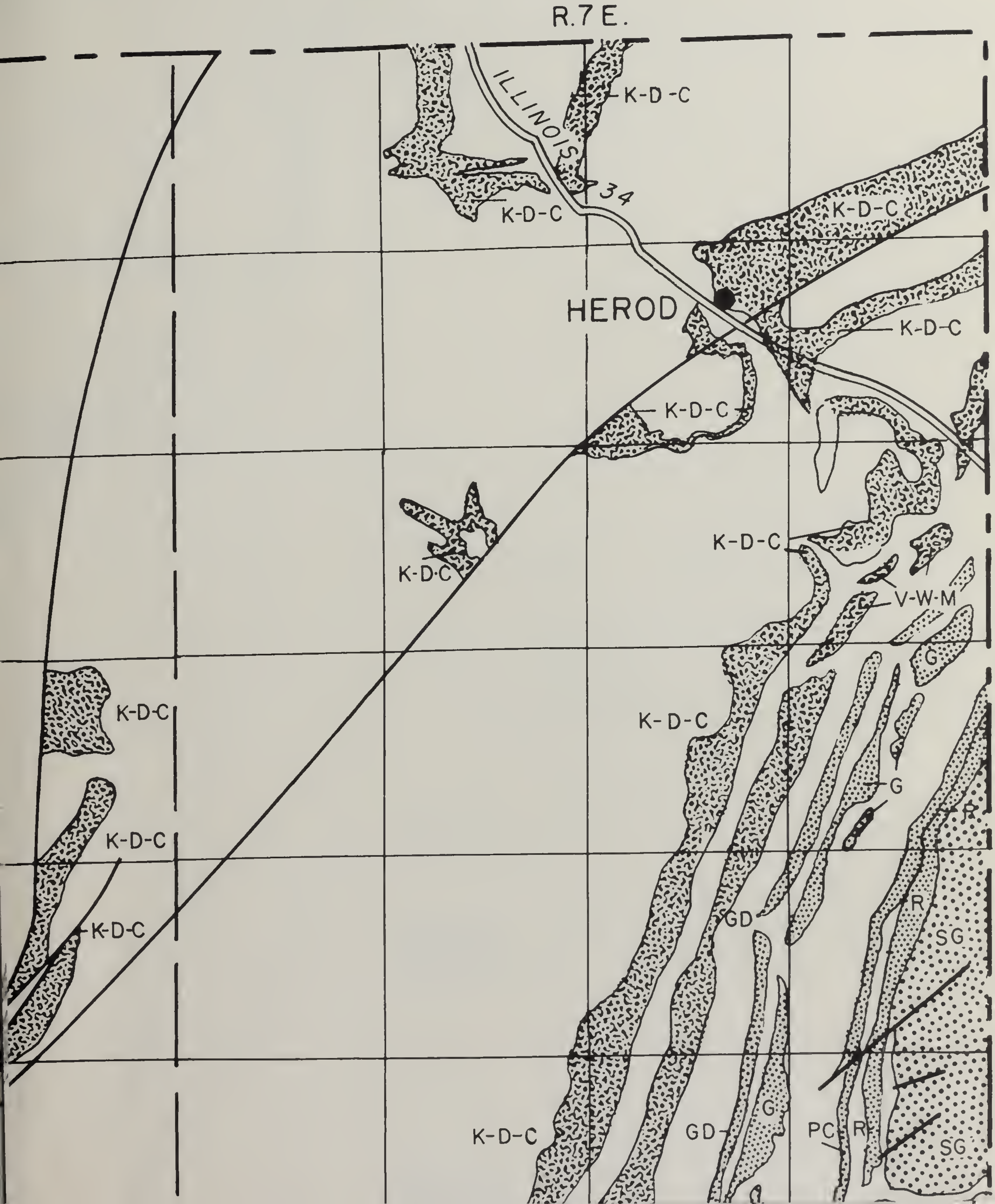
LIMESTONE RESOURCES IN MASSAC AND PULASKI COUNTIES

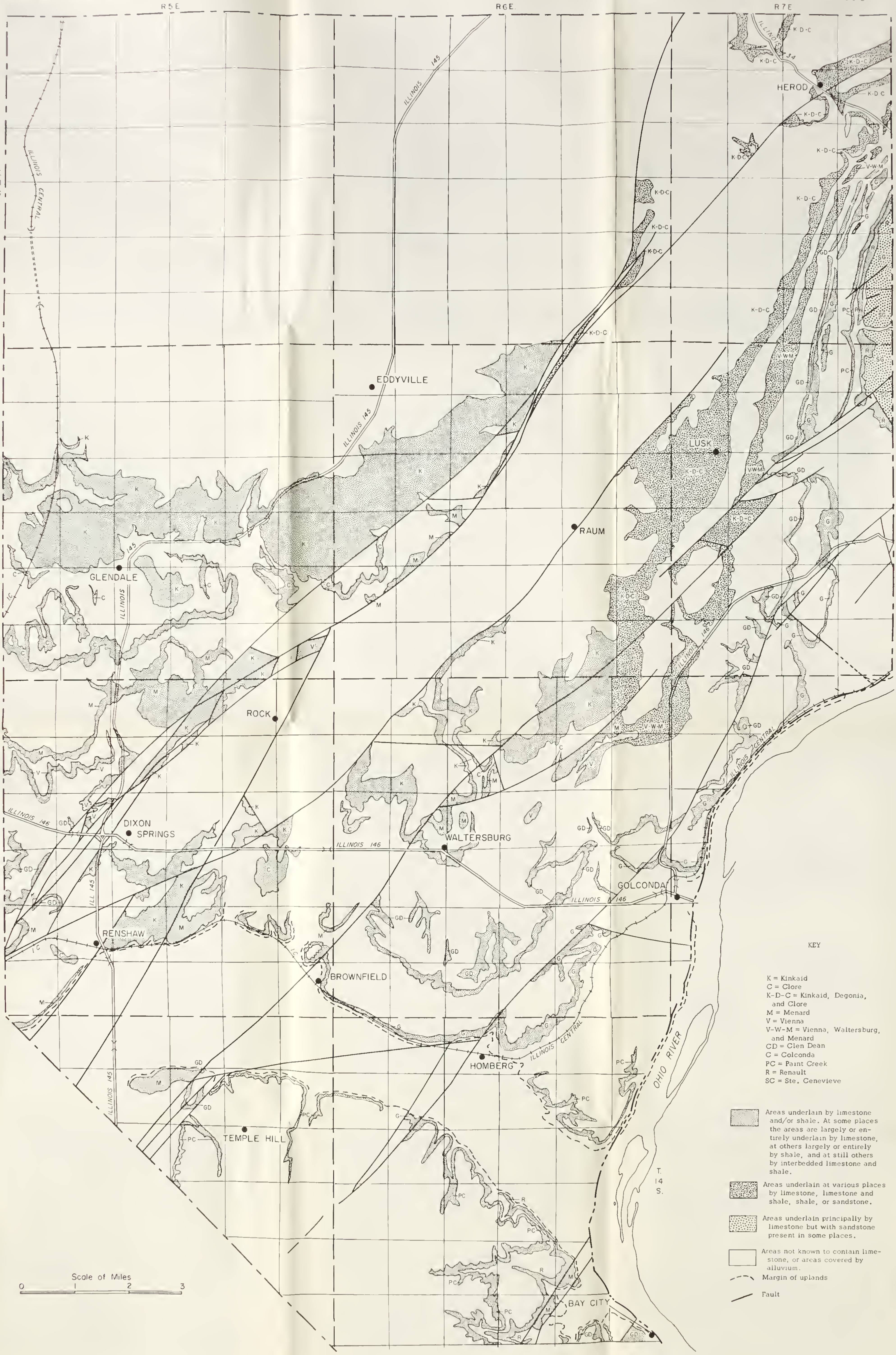
J. E. LAMAR

1958

Modified from S. Weller, and F. Krey

Report of Investigations 211 — Plate 5





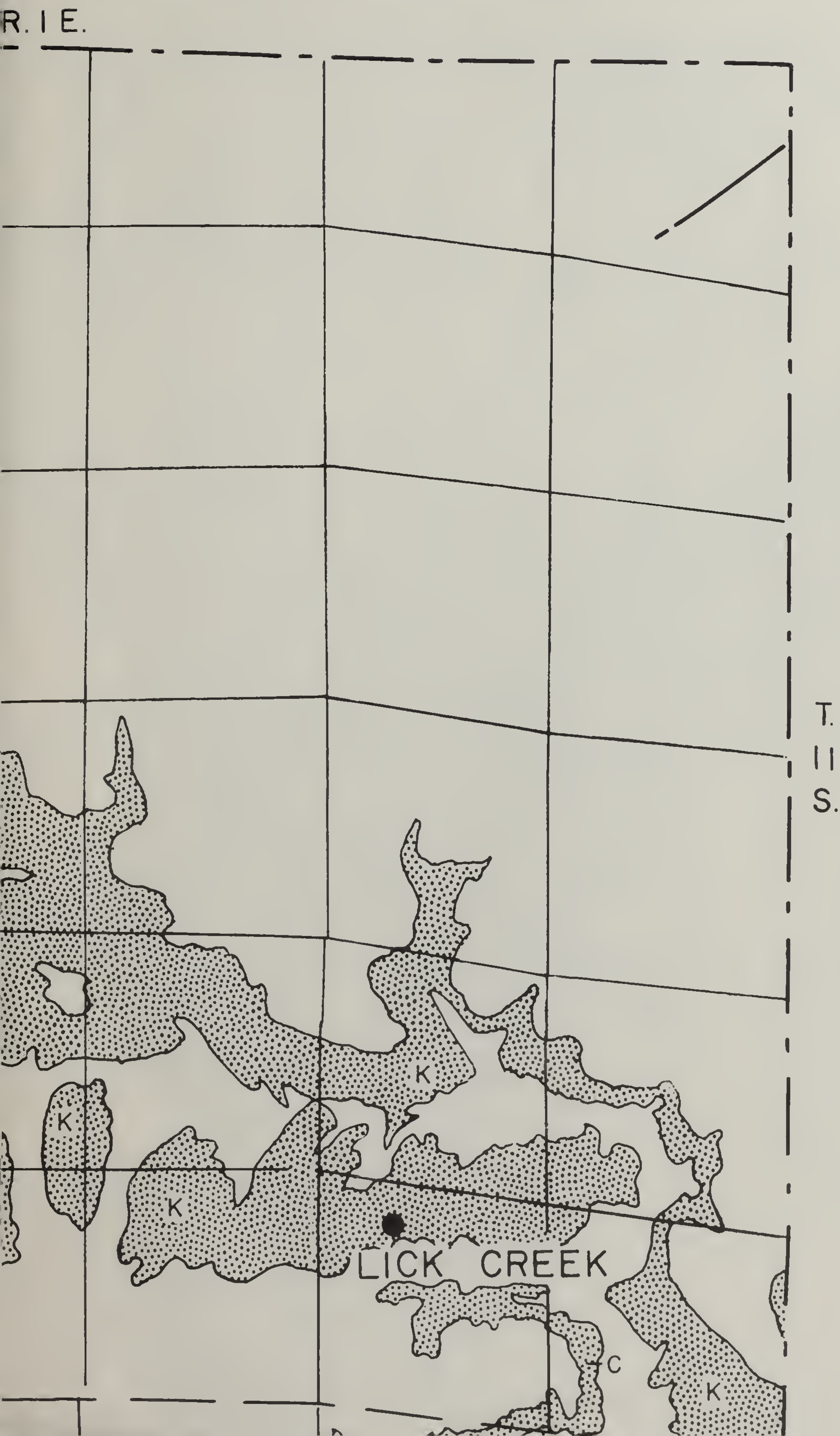
LIMESTONE RESOURCES IN POPE COUNTY

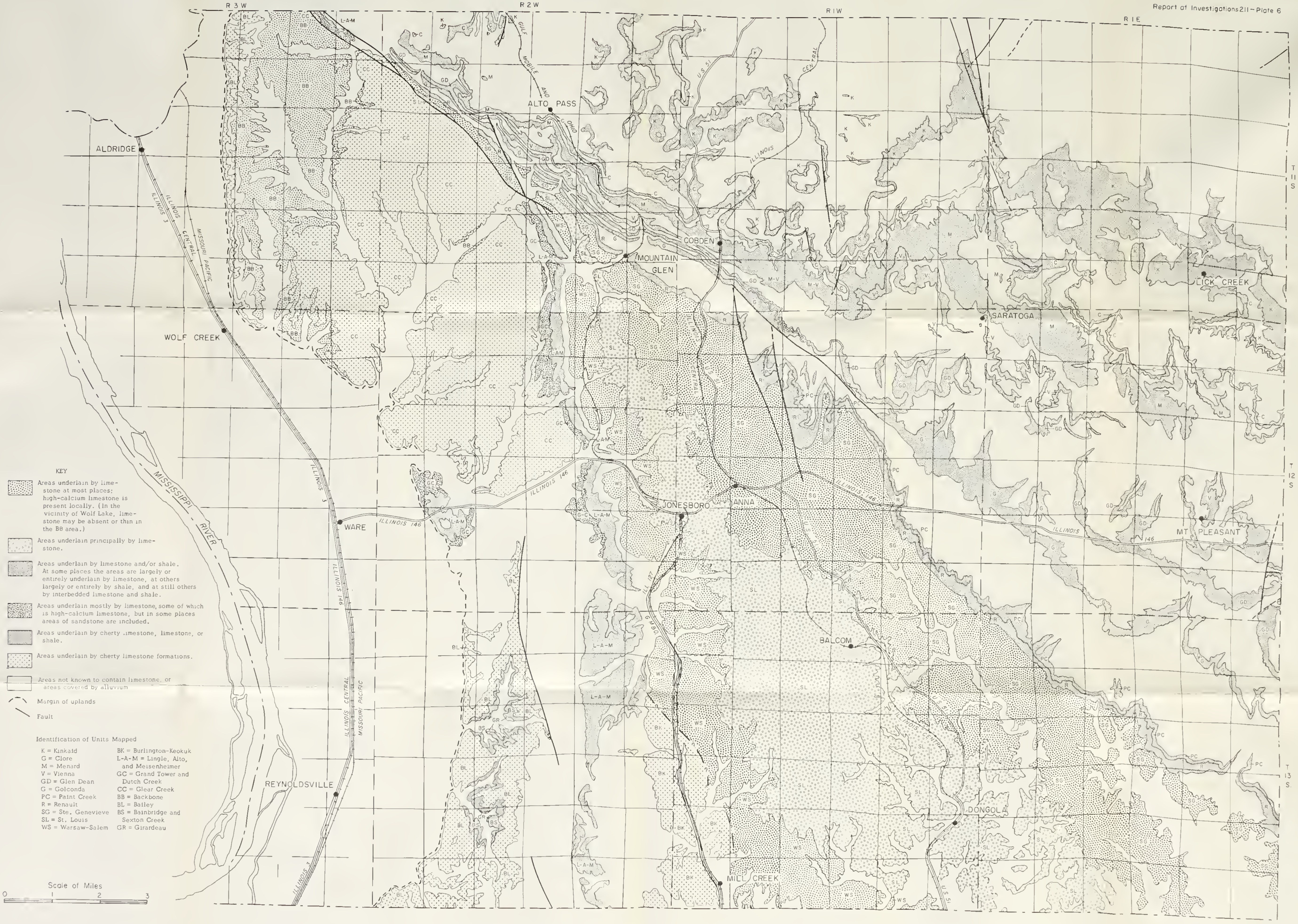
J. E. LAMAR

1958

Modified from S Weller, 1920; S. Weller and F. Krey, 1939; and J. M. Weller, R. M. Grogan and F Tippie, 1952

Report of Investigations 211 – Plate 6





LIMESTONE RESOURCES IN UNION COUNTY

J. E. LAMAR

1958

Modified from J M Weller and G E. Ekblaw, 1940; J. E. Lamar, 1925, and S. Weller, and F. Krey, 1939